NASA
Reference
Publication
1112

June 1983

User's Guide for the Solar Backscattered Ultraviolet (SBUV) and the Total Ozone Mapping Spectrometer (TOMS) RUT-S and RUT-T Data Sets: October 31, 1978 to November 1, 1980

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NASA

25th Anniversary
1958-1983

NASA Reference Publication 1112

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Acknowledgements

We would like to acknowledge N. Gupta and E. Suhari of SASC for help in preparation of the document; C. Lusby and J. Terry of SASC for word processing support in the preparation of the User's Guide; and L. Bowlin and D. Hammond of SASC and L. Novak of Goddard Space Flight Center for development of the RUT generation software.

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PREFACE

Nimbus Experiment Team (NET) Validation Statement for First and Second Year SBUV/TOMS Ozone Data Sets

Total ozone and ozone vertical profile results for Solar Backscattered Ultraviolet/Total Ozone Mapping Spectrometer (SBUV/TOMS) operation from November 1978 to November 1980 are available. The algorithms used have been tested, the instrument performance examined, and the ozone results have been compared with Dobson, Umkehr, balloon, and rocket observations. The accuracy and precision of the satellite ozone data is good to at least within the ability of the the ground truth to check.

The primary input to the ozone retrieval algorithms is the ratio of the backscattered radiance to the incident solar irradiance. Radiance and irradiance are each measured separately by both the SBUV and TOMS instruments. Accuracy in the determination of the radiance/irradiance ratio depends upon the calibration accuracy of a diffuse reflector used to measure the solar irradiance. Precision in the measurement of the radiance/irradiance is better than 0.5% for SBUV and 1.0% for TOMS. Analysis indicates that the instrument diffuser used for measuring solar flux had degraded by .8% at 339.8 nm and 2.3% at 273.5 nm by the end of the first year. By the end of the second year the degradation of the diffuser had reached 3.5% at 339.8 nm and 10.5% at 273.5 nm. The acceleration of the degradation is due to the more frequent deployment of the diffuser in the second year. The uncertainty of the estimated diffuser degradation is ± 20% of the magnitude of the degradation at the end of the second year. The second year ozone data processing includes a correction for diffuser degradation but the first year did not. This introduces an artifact in the ozone data for the first year. Diffuser degradation appears to be linear with time during the first year and the error in the derived ozone increases linearly until the end of the first year data set (Oct 1979); from then on no significant error due to diffuser degradation is expected to be present in the ozone data set. This will introduce a downward drift in the ozone derived by SBUV/TOMS for the first year at a rate that varies with height from 5% in one year at 1 mb to less than 1% at 10 mb; in total ozone the drift is estimated to be about 0.5% in one year for both SBUV and TOMS. This drift causes the annual average first year ozone to be too low by half of this amount. Measured against Dobson, total ozone derived by TOMS has increased from year 1 to year 2 by 0.34 ± 0.17%; similarly, comparison of SBUV with layer 9 (1-2 mb) Umkehr ozone shows an increase of 5.0 ± 1.3% from year 1 to year 2. Most of this is explained by the uncorrected diffuser degradation in the first year. We are continuing to assess the instrument performance as the third and fourth years of data are becoming available.

Total ozone has been derived from both the SBUV and TOMS instruments. Analysis of the variance of comparisons between colocated TOMS and AD pair direct sun (00 code) Dobson observations at solar zenith angles up to 70° shows that total ozone retrieval precision is better than 2%. In the first year there are biases of -6.5% and -8.3% for TOMS and SBUV respectively when compared to the Dobson network; in the second year the biases reduce to -6.2% and -8.0% respectively. If new ozone absorption coefficients available on a preliminary basis from the National Bureau of Standards were used for both SBUV/TOMS and the Dobson measurements, the biases would be 3 and 0% respectively.

Vertical profiles of ozone have been derived from the SBUV step scan radiances using an optimum statistical inversion algorithm. The inferred SBUV profiles are determined primarily by the measurements for an altitude range which typically extends from 0.7 mbar ($\sim$50 km) down to the peak of the ozone density profile, 20-40 mb ($\sim$22-26 km). This altitude range depends on several factors including the solar zenith angle, the total ozone amount, and the shape of the ozone profile. The reported layer ozone amounts below this region depend substantially on the **a priori** statistical information about the ozone variance in these layers as well as on the observed total ozone and upper level profile amounts.

The Nimbus-4 BUV ozone data archived at NSSDC in 1980 was derived from an algorithm different from that used for SBUV/TOMS. Comparison of 1970-1977 Ozone values from N4 with ozone values for 1978 and on from Nimbus 7 will contain substantial artifacts unless this algorithmic change is accounted for.

Variations of UV solar flux associated with the rotation of active regions on the sun with a 27-day solar rotation period have been observed with the continuous scan solar flux observations (160-400 nm). However, no significant solar flux variation was observed at the wavelengths used for the total ozone and vertical profile retrievals except at 273.5 nm with an amplitude less than 1/2%. In the processing of the first year data, a long term smoothed solar flux with no 27 day component was used at all wavelengths including 273.5 nm. This could have introduced a small (less than 1/2 %) artifact in the upper level ozone data. In the processing of the second year data the possibility of such error has been eliminated by using the short term smoothed solar flux data which reflect the 27 day variability at 273.5 nm.

The second year SBUV/TOMS ozone data sets have not been corrected for the effects of the Mt. St. Helen volcano that erupted starting May 18, 1980. In areas where the volcanic cloud had been known to be present the total ozone values derived by the algorithm show increases of up to 200 m-atm-cm. This effect is most likely caused by the presence of SO_2 in the volcanic cloud. As the cloud disperses and the SO_2 is converted to sulfate aerosols this effect disappears with a time constant that has not yet been determined. Since this particular volcanic cloud did not reach very high altitudes its effect on the SBUV profiles above the ozone density peak is not significant.

Ground truth for the validation of SBUV ozone profiles is severely limited; there are fewer than ten Umkehr and ozonesonde stations that report ozone profiles with any regularity and only eight individual ozone rocketsonde profiles taken during the SBUV overpass are so far available. Based on this limited amount of data it is not possible to determine accurately the quality of SBUV profiles at all heights or to evaluate possible latitudinal and temporal trends in the SBUV data. The bias between SBUV and the ground based sensors is less than 10% at all altitudes between 20-50 km and the SBUV precision is better than 5%. Some of the observed bias could be due to errors in the ozone absorption cross-sections used in the retrieval schemes of both the satellite and ground sensors, and to the effects of aerosols and dust on Umkehr-derived ozone.

Comparison of balloon data with SBUV results from the Payerne and Hohenpeissenberg stations confirms that the profile data has substantial information content even below the ozone maximum (i.e. from 25 km to the surface). We estimate a precision better than 10% in layers 4 and 5 and better than 15% in layer 3 and 20% in layer 2. It is clear that the retrievals provide better information in the mid latitudes than can be derived solely from knowledge of total ozone and climatology.

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USER'S GUIDE FOR THE SOLAR BACKSCATTERED ULTRAVIOLET (SBUV) AND THE TOTAL OZONE MAPPING SPECTROMETER (TOMS) RUT-S AND RUT-T DATA SETS:

October 31, 1978 to November 1, 1980

1. SBUV AND TOMS EXPERIMENTS

1.1 INTRODUCTION

This guide is intended for the users of the Nimbus 7 SBUV and TOMS Raw Unit Tapes, RUTs. It accompanies the first two years of the RUT data sets covering the period October 31, 1978 to November 1, 1980. Two separate sets of RUTs exist for SBUV and TOMS, labelled RUT-S and RUT-T, respectively. The RUT-S and -T tapes contain uncalibrated radiance and irradiance data, housekeeping data, wavelength and electronic calibration data, instrument field-of-view location and solar ephemeris information. These tapes also contain cloud, terrain pressure and snow/ice thickness data, each derived from an independent source.

A brief overview of the two experiments and of the data processing used to generate these two data sets is given in Section 1. Section 2 contains a discussion of each instrument's performance and calibration based on observations of the solar spectral irradiance and the ratio of the backscattered spectral radiance to the solar spectral irradiance. In Section 3, the completeness of the two data sets is discussed. These data sets contain all available SBUV and TOMS data, the terrain pressure data and the snow/ice data. The cloud data is available on the average of 70 percent per day in year 1 and 85% in year 2; the reasons for this are also included in Section 3. In Section 4 the quality of the two data sets is discussed and the known errors are listed. The overall quality of these data sets is very good with no known major errors. Sections 5 and 6 contain the tape formats and details of the tape contents for the RUT-S and RUT-T, respectively. Additional useful information is included in several appendices. Appendix A contains the wavelength channels for both SBUV and TOMS. Appendix B describes the merged cloud, terrain and snow/ice data. Appendix C describes the housekeeping information for both SBUV and TOMS. Appendices D and E contain the RUT-S and RUT-T Tape Catalogs. Appendix F provides information on data acquisition. Appendix G contains a glossary of abbreviations used in this document. Appendix H contains a brief summary of data available from the Nimbus 4 BUV experiment.

1.2 SBUV EXPERIMENT

The Solar Backscattered Ultraviolet instrument (SBUV) onboard the Nimbus 7 satellite is designed to measure the total ozone and its distribution with height in the atmosphere in a vertical column beneath the satellite (ref. 1). This experiment is an improved version of the Backscattered Ultraviolet (BUV) experiment onboard the Nimbus 4 satellite. The computation of total ozone and ozone profiles from SBUV data is described by Fleig et al (ref. 2). The SBUV contains a double monochromator and a filter photometer designed to measure UV spectral intensities. The monochromator serially monitors 12 narrow wavelength bands in the near-UV spectral region from 255.6 nm to 339.9 nm, each with a bandpass of 1.0 nm. The band center wavelengths are given in Appendix A. The monochromator can also scan continuously in the wavelength range from 160.0 nm to 400.0 nm with increments of 0.2 nm. For every monochromator measurement in the step scan mode the photometer takes a simultaneous measurement in a fixed band centered at 343.0 nm with a 3.0 nm bandwidth. The photometer measures the effective UV reflectivity of the surface in the instantaneous field of view (IFOV) and monitors reflectivity changes in the course of a scan. The SBUV also makes periodic measurements of the solar flux by deploying a diffuser plate into the field of view (FOV) to reflect sunlight into the instrument. The diffuser is a roughened aluminum plate which can be deployed in one of three positions — SBUV, TOMS and STOW. The diffuser is also used to intercept radiation from an onboard low pressure mercury-argon lamp used for inflight wavelength calibration. During wavelength calibration, five wavelengths centered near 253.7 nm with 0.5 nm steps are sampled.

The double monochromator and the photometer are mounted so that they look in the nadir direction with coincident FOVs of $11.3^{\circ} \times 11.3^{\circ}$. As the satellite moves in a sun-synchronous retrograde orbit, the IFOV traces out 200 km wide swaths on the ground separated by 26° longitude intervals between successive orbits. The satellite footprint moves at a speed of roughly 6 km/sec. SBUV has five operating modes which determine data processing sequences, data formats and the SBUV wavelength cam operation. These modes are:

- Step scan mode
- Wavelength calibration mode
- Cage cam mode

- Continuous scan mode
- Scan off mode

These modes are briefly described here and the data format corresponding to each mode is discussed in Section 5.2.

1.2.1 Step Scan Mode (Mode 1)

This is the primary operating mode of the SBUV. In this mode the SBUV measures photometric responses at each of the 12 wavelength channels listed in Appendix A. The wavelength cam is sequentially driven from the 339.9 nm to the 255.6 nm position. The first measurement occurs 0.88 second after the start of the scan. After reaching each wavelength position, the cam stops and a 1-second integration is performed. After this the cam advances to the next position requiring approximately 0.5 second. The cycle repeats until all 12 wavelength positions have been covered (in 18 seconds). After completing the last measurement, the cam continues until the cage position is reached. The entire sequence requires 32 seconds (two VIP major frames) and is repeated until a different mode command is issued. Solar flux measurements are taken typically once a week by deploying the diffuser plate while operating the instrument in this mode.

1.2.2 Wavelength Calibration Mode (Mode 2)

This mode is similar to Mode 1 except different wavelengths are sampled. The five wavelength positions sampled in sequence are: (1) 254.7 nm, (2) 254.2 nm, (3) 253.7 nm, (4) 253.2 nm and (5) 252.7 nm. Each measurement cycle requires 32 seconds (two VIP major frames). The SBUV remains in this mode until commanded otherwise. For wavelength calibration the mercury-argon lamp is turned on and the diffuser plate is moved to the SBUV position. Wavelength calibration measurements are taken typically twice per week.

1.2.3 Cage Cam Mode (Mode 3)

The cage cam command causes the SBUV wavelength cam to move and stay in the cage position. During this mode the data is sampled at 408.8 nm at the rate of one sample per second.

1.2.4 Continuous Scan Mode (Mode 4)

During this mode, the SBUV scans from 160 nm to 400 nm in 0.2 nm increments sampling data at 80 millisecond intervals. One complete wavelength scan in this mode requires 112 seconds (seven VIP major frames). During the first major frame the SBUV wavelength cam advances to the beginning of the spectral region and the complete data sampling is done during the next six major frames. Solar flux measurements are taken in this mode by deploying the diffuser plate near the northern terminator crossing. This is done normally once per day, although there were periods when it was done once per orbit.

1.2.5 Scan Off Mode (Mode 5)

The command for this mode causes the SBUV wavelength cam motion to cease. During this mode the SBUV samples data once per second at the wavelength determined by the current wavelength cam position.

1.3 TOMS EXPERIMENT

The Total Ozone Mapping Spectrometer (TOMS) is designed to provide daily global coverage of the earth's total ozone (ref. 1). Mapping is done by scanning through the subsatellite point in a direction perpendicular to the orbit plane. The TOMS instrument has a single monochromator with a 3° x 3° FOV which samples backscattered UV solar radiation at six wavelengths from 312.5 nm to 380.0 nm with a 1 nm bandwidth. The wavelength channels for TOMS are given in Appendix A. TOMS has a scanning mirror which scans cross course 51° each side of the nadir in 3° steps. One complete cross scan takes 8 seconds and 35 samples are taken during this time. This scanning motion together with the fact that consecutive scans overlap, creates a contiguous mapping of ozone. The computation of total ozone from TOMS data is described by Fleig et al (ref. 3).

The TOMS instrument shares the diffuser plate with the SBUV for solar irradiance measurements. The inflight wavelength calibration for TOMS works on the same principle as that for the SBUV except a different mercury emission line (296.7 nm) is used. The following four wavelengths are sampled: (1) 297.5 nm, (2) 297.0 nm, (3) 296.5 nm and (4) 296.0 nm. The TOMS scanner has four scanner modes:

- Single step mode
- Normal scan mode

- Stowed mode
- View diffuser mode

In single step mode, the scanner is controlled by ground commands. In the normal scan mode, the scanner scans 35 scenes corresponding to all the scanner view angles; it then retraces to the first position and starts another scan of 35 scenes. This is the primary scanner mode for the TOMS. In the stowed mode, the scanner slews to the stowed position and stops. This mode is required for the TOMS wavelength calibration. In the view diffuser mode, which is required in solar spectral irradiance measurement, the scanner moves to the view diffuser position and stops. One solar flux measurement is normally taken weekly with TOMS.

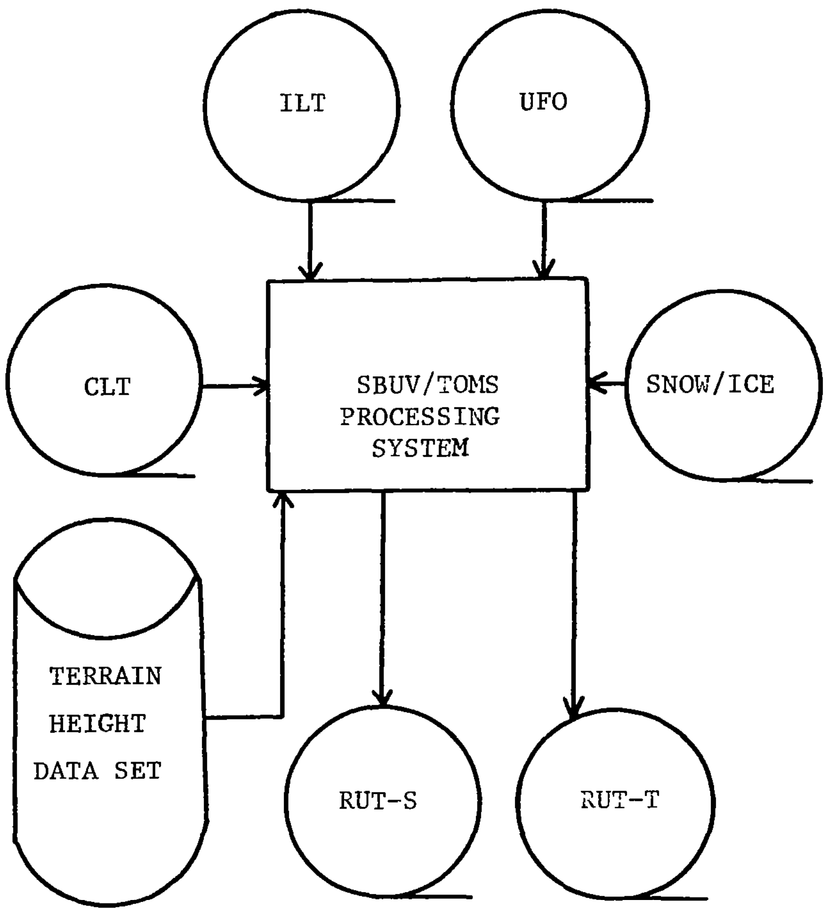
1.4 DATA PROCESSING

The RUT-S/T tapes are derived by combining the SBUV/TOMS Image Location Tape (ILT), User Formatted Output (UFO) tape, Cloud-SBUV/TOMS (CLT) tape, Snow/Ice tape and a Terrain Height data set as shown in Figure 1-1. The terrain height data set is obtained from the National Oceanic and Atmospheric Administration (NOAA). The snow/ice tapes are obtained from the Air Force Global Weather Center, National Climatic Center, Asheville, North Carolina. The CLT tape contains colocated cloud data for each IFOV of SBUV and TOMS measured by the Temperature Humidity Infrared Radiometer (THIR), onboard Nimbus 7 (ref. 4). Details of each type of the merged data are discussed in Appendix B.

In the data processing, first the instrument measurements on the UFO tape are combined with image location information on the ILT tape and the terrain height information on a disk data set. Later, the colocated cloud and snow/ice thickness data are merged to produce the final RUT-S/T tapes. This merging of four kinds of data is done for only the step-scan operating mode of SBUV and the normal scan mode of TOMS. The contents of the SBUV (RUT-S) data records for each operating mode are discussed in Section 5.2. Contents of the RUT-T tape are discussed in Section 6.2.

FIGURE 1-1

INPUTS FOR GENERATION OF RUT-S AND -T



2. INSTRUMENT CALIBRATION AND PERFORMANCE

2.1 PRELAUNCH RADIOMETRIC CALIBRATION AND INSTRUMENT PARAMETERS

The prelaunch radiometric calibration was performed at the sites of Beckman Instrument, Inc. and the Jet Propulsion Laboratory by the instrument manufacturer, Beckman Instrument, Inc., and repeated at General Electric after the final spacecraft thermal vacuum (T/V) test. The data obtained in the General Electric tests were used in the derivation of the final prelaunch calibration constants.

The radiometric calibration standards employed were spectral irradiance source standards of quartz halogen lamp, deuterium (D_2) arc and argon (Ar) mini arc. All these standards were obtained from National Bureau of Standards (NBS) and calibrated at NBS before and after the calibration tests. Table 2.1 shows the wavelength ranges for which the standards were used.

Since the instrument measures both radiance and irradiance, two different sets of calibration constants were obtained. The calibration for the radiance measurement mode (radiance calibration) required a diffuse reflector made of $BaSO_4$ to simulate a spectral radiance standard from the irradiance standard. The hemispherical reflectivity of the $BaSO_4$ diffuser was measured at NBS several different times to monitor the stability of the plate. The measured values were within $\pm 1\%$ of the mean value of all the measurements and the averaged value of the measurements immediately before and after was used in the computation of the calibration constant.

For a Lambertian surface, the spectral radiance, L_λ, of the surface when illuminated by an irradiance source may be expressed such that $L_\lambda = \frac{E_\lambda \cdot \alpha}{\pi}$ where E_λ is the spectral irradiance at the wavelength λ on the surface and α the hemispherical reflectance of the $BaSO_4$ diffuser. The radiance calibration constant, k_λ, can be determined from the following equation.

$$k_\lambda = \frac{L_\lambda}{c_\lambda}$$

where c_λ is the instrument output count corresponding to the spectral radiance L_λ. Since the distance from the calibration source to the points on the $BaSO_4$ plate within the field of view (FOV) of the instrument and the incidence angles vary, an averaged radiance

Table 2.1

Standards for the Calibration

Wavelength Range (nm)	Standard	Accuracy
160 - 200	Ar mini-arc	$\pm$10%
200 - 250	D_2 lamp	$\pm$6%
250 - 400	QI lamp	$\pm$2.6% at 250 nm
		$\pm$1.7% at 350 nm
		$\pm$1.4% at 450 nm

Note: All the standards are spectral irradiance source standards.

value within the FOV was used in the actual computation. Tables 2.2 and 2.3 show the final prelaunch radiance calibration constants for SBUV step scan and TOMS, respectively.

In the calibration for irradiance measurement mode (irradiance calibration), the instrument diffuser was deployed and directly illuminated by the calibration lamp as in the configuration of the solar irradiance measurement at the terminator. The irradiance calibration constant, K_λ, was computed with the following equation:

$$K_\lambda = \frac{E_\lambda}{C_\lambda}$$

where E_λ is the spectral irradiance on the instrument diffuser and C_λ the instrument output count for the spectral irradiance of E_λ. As in the case of the radiance calibration, the irradiance on the instrument diffuser varies due to both the variation of the distance between the calibration source and the point on the diffuser, and the variation of the incidence angle on the diffuser. An averaged value of E_λ within the field of view was used in the computation. Tables 2.4 and 2.5. list the final irradiance calibration constants for SBUV step scan and TOMS, respectively.

The angular response of the instrument for the solar flux measurement was also determined from the prelaunch test and verified with the in-orbit data. The relative angular response of the instrument can be represented by the following analytic function (called the goniometric function):

$$F_1(\alpha,\beta)=b_o + b_1 \alpha + b_2 \beta + b_3 \alpha^2 + b_4 \alpha\beta + b_5 \beta^2 + b_6 \alpha^3 + b_7 \alpha^2 \beta + b_8 \alpha\beta^2 + b_9 \beta^3$$

where α is the solar elevation angle, and β the angle between the sun-earth vector and the satellite orbital plane. The values of the coefficients are given in Table 2.6. Two sets of coefficients are given for SBUV to cover two separate ranges for the β angle, corresponding to two parts of the equation of time during the year.

The signal which SBUV/TOMS is to measure varies by several orders of magnitude requiring a wide dynamic range of the instrument. This requirement is achieved by employing several gain ranges with the electronic amplifier. The gain ratios between different gain ranges are shown in Table 2.7. Table 2.8 lists the wavelengths of the band center of the SBUV step scan and TOMS channels.

Table 2.2

SBUV Step Scan Radiance Calibration Constants
For Gain Range 2 ($W/cm^3/Ster/Count$)

Wavelength (nm)	k_λ
339.9	0.4463×10^{-4}
331.2	0.5203×10^{-4}
317.6	0.6188×10^{-4}
312.6	0.6268×10^{-4}
305.9	0.6347×10^{-4}
302.0	0.6366×10^{-4}
297.6	0.6352×10^{-4}
292.3	0.6274×10^{-4}
287.7	0.6157×10^{-4}
283.1	0.5978×10^{-4}
273.6	0.5506×10^{-4}
255.7	0.5102×10^{-4}
343*	0.1853×10^{-2}

*Photometer

Table 2.3

TOMS Radiance Calibration Constants

For Gain Range 1 ($W/cm^3/ster/count$)

Wavelength (nm)	k_λ
380.0	0.2971×10^{-3}
360.0	0.3309×10^{-3}
339.9	0.3381×10^{-3}
331.3	0.3483×10^{-3}
317.5	0.3731×10^{-3}
312.5	0.3995×10^{-3}

Table 2.4

SBUV Step Scan Irradiance Calibration Constants

For Gain Range 2 (W/cm^3/count)

Wavelength (nm)	K_λ
339.9	0.2399×10^{-3}
331.3	0.2811×10^{-3}
317.6	0.3377×10^{-3}
312.6	0.3429×10^{-3}
305.9	0.3499×10^{-3}
302.0	0.3529×10^{-3}
297.6	0.3551×10^{-3}
292.3	0.3545×10^{-3}
287.7	0.3513×10^{-3}
283.1	0.3442×10^{-3}
273.6	0.3209×10^{-3}
255.7	0.3020×10^{-3}
343*	0.1011×10^{-1}

*Photometer

Table 2.5

TOMS Irradiance Calibration Constants

For Gain Range 1 ($W/cm^3/count$)

Wavelength (nm)	K_λ
380.0	1.579×10^{-3}
360.0	1.765×10^{-3}
339.9	1.823×10^{-3}
331.3	1.888×10^{-3}
317.5	2.033×10^{-3}
312.5	2.183×10^{-3}

Table 2.6

Goniometric Function Coefficients

$$F_1(\alpha,\beta) = b_o + b_1\,\alpha + b_2\,\beta + b_3\,\alpha^2 + b_4\,\alpha\beta + b_5\,\beta^2 + b_6\,\alpha^3 + b_7\,\alpha^2\,\beta + b_8\,\alpha\beta^2 + b_9\,\beta^3$$

	SBUV		TOMS
Coefficient	$F_1\ (\alpha,\beta)$	$F_1\ (\alpha,\beta)$	$F_1\ (\alpha,\beta)$
b_0	1.0031	1.0022	1.000
b_1	$-.1563 \times 10^{-1}$	-0.1569×10^{-1}	-0.4577×10^{-3}
b_2	$-.1114 \times 10^{-2}$	-0.1077×10^{-2}	0.1311×10^{-1}
b_3	$.6234 \times 10^{-3}$	0.6222×10^{-3}	0.1078×10^{-2}
b_4	$-.3625 \times 10^{-5}$	0.3848×10^{-4}	0.1041×10^{-3}
b_5	$.5078 \times 10^{-3}$	0.6490×10^{-3}	0.2640×10^{-3}
b_6	$-.7606 \times 10^{-5}$	0.6992×10^{-5}	-0.1862×10^{-4}
b_7	$.2814 \times 10^{-6}$	-0.1905×10^{-6}	-0.8539×10^{-6}
b_8	$-.6363 \times 10^{-6}$	-0.8341×10^{-5}	0.2576×10^{-5}
b_9	$.1189 \times 10^{-5}$	-0.1211×10^{-4}	-0.1787×10^{-4}
angular range	$-5^\circ \le \alpha \le 18^\circ$ and $-4.8^\circ \le \beta \le 5^\circ$	$-3^\circ \le \alpha \le 18^\circ$ and $-4.3^\circ \le \beta \le 7.5^\circ$	

Note: The first column for the SBUV goniometric function is to be used with data obtained for day 302 of the year through day 118 of the next year. The second column is for day 119 through day 301 of the year.

Warning: We suspect that the β dependence of the goniometric calibration function presented above may be in error. Since the solar azimuth angle β varies with season, the error in the solar flux derived with the function above would also be seasonally dependent. We estimate that the peak-to-peak error in the function above is approximately 2.5%. A new goniometric calibration function is now being derived and validated and will be available in July 1983 from the authors.

Table 2.7

Gain Ratios Between SBUV/TOMS Ranges

Ranges	SBUV Gain Ratio	TOMS Gain Ratio
$\frac{R1}{R2}$	52.42[a)]	6.6
$\frac{R2}{R3}$	80.50[a)]	7.2
$\frac{R3}{R4}$	N/A	7.2[a)]

a) These ratios were determined from the inflight data.

Table 2.8

Peak Wavelengths for SBUV/TOMS Channels

SBUV		TOMS	
Channel	Wavelength (nm)	Channel	Wavelength (nm)
3398	339.892	3800	380.014
3312	331.261	3600	359.962
3175	317.561	3398	339.861
3125	312.565	3312	331.253
3058	305.872	3175	317.512
3019	301.972	3125	312.514
2975	297.586		
2922	292.289		
2876	287.702		
2830	283.099		
2735	273.608		
2555	255.652		

2.2 IN-ORBIT INSTRUMENT PERFORMANCE

This section presents a description of the instrument performance as determined from the inflight calibration data. At present, changes in the instrument characteristics after launch have not been determined for the absolute solar spectral irradiance and the earth radiance. However, the ratio of these two values (which is the physical quantity necessary for the ozone computation) can be determined within the accuracy with which we can characterize changes of the instrument diffuser. The following paragraphs will show results from the inflight calibration and discuss the estimation of the diffuser characteristic change.

SBUV/TOMS has two inflight calibration features: 1) wavelength calibration and 2) electronic calibration. Wavelength calibration is to monitor the change of the peak wavelength of the instrument channels as described in the previous section. Electronic calibration is to monitor the gain of the instrument electronic amplifier by injecting several predetermined levels of constant current into the input stage of the amplifier. SBUV has an additional feature to monitor the photomultiplier (PMT) gain. A small fraction (10%) of the beam coming out from the monochromator exit slit is diverted by a mirror to a photodiode. Since the gain of the photodiode is 1, the ratio of the PMT output to the reference photodiode can be used to monitor the PMT gain change due to the dynode degradation.

Tables 2.9 and 2.10 list the wavelength calibration results for SBUV and TOMS, respectively. No significant change is observed in either of the instruments. Table 2.11 and 2.12 show the electronic calibration data for SBUV and TOMS, respectively. No significant change is seen in this data either.

The ratio of the PMT output to the reference diode of SBUV is shown in Figure 2.1 for the 339.9 nm channel. The initial rapid decrease of the ratio (within 2 months of operation) indicates a decrease of the photomultiplier gain. Such a decreasing trend was also observed during the course of the prelaunch tests. The ratio seems to reach a minimum and then increases slightly toward the end of the first year. This could be due to recovery of the photomultiplier gain or to a slow degradation of the reference diode channel. The cause of this is not known. Nonetheless, it is important to note that the uncertainty in the photomultiplier gain affects only the absolute measurements of the irradiance and radiance but not their ratio.

Table 2.9

SBUV Wavelength Calibration Data

ORBIT	DAY	λ_p	σ	TEMP.
Prelaunch	GE T/V	2535.78		10°C
Prelaunch	GE T/V	2536.01		35°C
198	11/7/78	2535.91	0.02	23.4°C
1366	1/31/79	2535.92	0.04	21.9°C
1487	2/8/79	2535.91	0.05	21.5°C
1683	2/23/79	2535.90	0.05	21.5°C
1177	3/1/79	2535.88	0.01	21.1°C
1943	3/13/79	2535.91	0.01	21.1°C
2014	3/18/79	2535.92	0.01	21.5°C
2109	3/25/79	2535.94	0.01	20.7°C
2261	4/5/79	2535.92	0.02	21.9°C
2572	4/28/79	2535.89	0.04	20.7°C
2792	5/14/79	2535.90	0.06	21.1°C
2932	5/24/79	2535.91	0.04	20.7°C
3507	7/4/79	2535.88	0.03	21.9°C
3894	8/1/79	2535.86	0.04	21.9°C
4860	10/10/79	2535.92	0.01	23.0°C
4960	10/18/79	2535.90	0.02	22.6°C
4989	10/20/79	2535.88	0.03	22.1°C
5015	10/22/79	2535.92	0.03	22.6°C
5042	10/24/79	2535.99	0.01	20.4°C

Table 2.10

TOMS Wavelength Calibration Data

ORBIT	DAY	λ_p	σ	TEMP.
Prelaunch	GE T/V	2965.19		10°C
Prelaunch	GE T/V	2965.33		35°C
100	10/31/78	2965.24	0.03	
198	11/7/78	2965.25	0.03	
400	11/22/78	2965.25	0.03	
492	11/28/78	2965.23	0.03	
1366	1/31/79	2965.23	0.03	
1487	2/8/79	2965.21	0.03	
1683	2/23/79	2965.23	0.03	
1777	3/1/79	2965.20	0.03	
1943	3/13/79	2965.21	0.03	
2109	3/25/79	2965.21	0.02	
2261	4/5/79	2965.24	0.03	
2414	4/16/79	2965.22	0.03	
2572	4/28/79	2965.22	0.03	
2792	5/14/79	2965.22	0.03	
4860	10/10/79	2965.22	0.03	
4960	10/18/79	2965.22	0.03	
4989	10/20/79	2965.22	0.03	
5015	10/22/79	2965.22	0.03	
5042	10/24/79	2965.22	0.03	

Table 2.11

SBUV Electronic Calibration Data

Level	Channel	106 10/13/78	198 11/7/78	1366 1/31/79	2014 3/18/79	2572 4/28/79	3507 7/4/79	3894 8/1/79	4960 10/18/79	4989 10/20/79
0	G2	44170	44157	44108	44102	44093	44096	44095	44685	44421
	G3	562	579	563	557	550	558	564	581	571
	Photo	41394	41320	41176	41114	41124	41109	41105	41441	41285
1	G2	70802	70782	70679	70668	70660	70659	70656	70649	70652
	G3	911	909	905	908	903	908	907	907	907
	Photo	66318	66274	65991	65965	65937	65910	65903	65884	65883
2	G1	15700	15693	15689	15646	15657	15670	15657	15663	15055
	Ref.	6561	6561	6594	6603	6596	6596	6595	6608	6608
3	G1	25168	25144	25142	25117	25102	25115	25119	25096	25109
	Ref.	10558	10548	10585	10601	10593	10599	10602	10607	10611

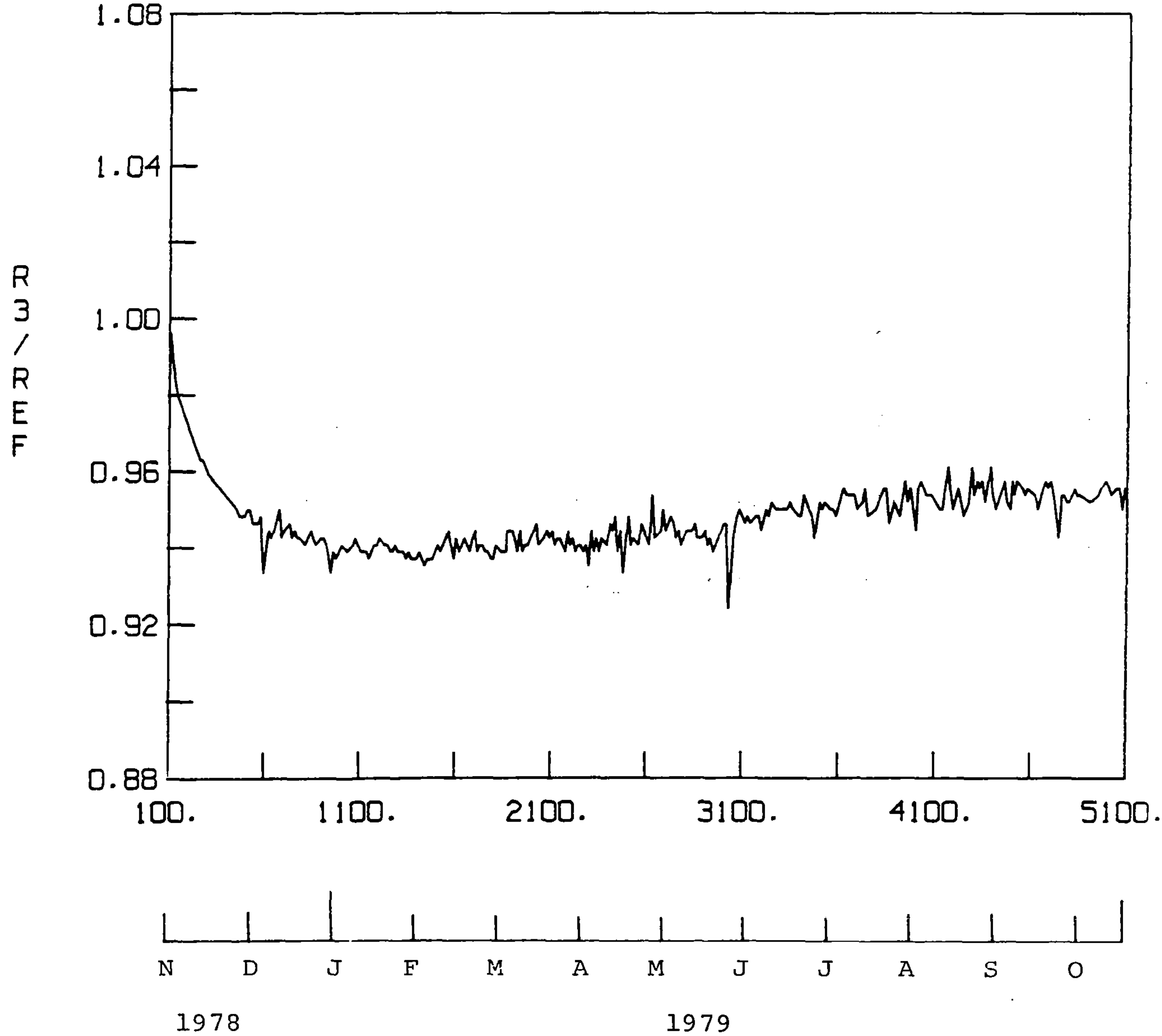
Table 2.12

TOMS Electronic Calibration Data

Orbit Day	106 10/31/78	198 11/7/78	1366 1/31/79	2015 3/18/79	2572 4/28/79	4960 10/18/79	4989 10/20/79
Level 0 G3	1615	1608	1608	1610	1609	1608	1608
Level 1 G3	2560	2560	2544	2544	2559	2548	2544
Level 2 G2	1816	1816	1816	1816	1815	1815	1816
Level 3 G2	2880	2880	2880	2880	2880	2880	2880
Level 4 G1	1832	1831	1832	1830	1831	1831	1832
Level 5 G1	2912	2912	2912	2910	2911	2911	2912
Level 6 G0	1884	1883	1881	1881	1881	1880	1881
Level 7 G0	2992	2992	2992	2993	2992	2922	2922

Figure 2.1

The Relative Ratio of the Photomultiplier Output to the Reference Diode for the 339.9 nm Channel as a Function of Orbit



We have identified clearly diffuser plate degradation and have determined it's magnitude for the first two years (see Addendum to Ozone-S User's Guide - ref. 5). We are continuing our analysis to determine time dependent correction functions for the absolute radiances and irradiances as measured by SBUV and TOMS. We regret that these functions are not as yet available.

2.3 CALIBRATION FOR ALBEDO MEASUREMENT

Time-dependent calibration functions have been determined for the radiance to irradiance ratio. These functions can be found in the Ozone-S and Ozone-T user's guides and addenda (Refs. 2,3,5 and 6).

3. OPERATING SCHEDULES AND DATA COVERAGE

The first two years of the RUT-S and -T data sets cover the time period from October 31, 1978 to November 1, 1980. The SBUV and TOMS scan data and the merged terrain pressure and snow/ice data on these tapes are complete. The colocated THIR cloud data coverage is close to 70 percent for year 1 and 85% for year 2.

3.1 OPERATING SCHEDULE FOR SBUV

An orbit by orbit inventory of the SBUV step scan and continuous scan data is available from NSSDC (ref. 7). According to this inventory no regular ON/OFF schedule was followed in the first seven months of instrument operation. Originally, the instrument was intended to be ON three days and OFF one day. However, in the beginning the instrument was ON continuously for 17 days before the first turn-off. The schedule did not become regular until May 28, 1979 (day 148 of 1979). Subsequently, the instrument schedule has followed a more or less regular pattern of three days ON and one day OFF.

During normal operation there are usually 13 to 14 orbits of step scan data available for each day the instrument is ON. Whenever fewer than this number of data orbits are available, one of the following two reasons is responsible:

1. The instrument is operating in one of the four non-step scan modes.
2. No data is available for processing due to losses in data transmission or handling.

On those days when the instrument is OFF, less than one orbit of data is available. SBUV is operated mostly in the step scan mode taking daytime earth-radiance measurements. The instrument also operates in four non-step scan modes. The most important of these modes for the user is the continuous scan mode. During this mode the instrument either measures the solar flux by deploying a diffuser plate or measures earth radiances.

The SBUV inventory classifies each orbit into the following categories:

- Orbits with daytime data (number of scans $\geq$ 75).
- Orbits with partial daytime data (75>number of scans $\geq$5).
- Orbits with nighttime data (number of scans $\geq$ 25).
- Orbits with no daytime data (number of scans <5).
- Continuous scan orbits

Additionally, the date of each orbit is given.

3.2 OPERATING SCHEDULE FOR TOMS

An orbit by orbit inventory (ref. 7) of the TOMS data is available from NSSDC. This inventory shows that in the first seven and one half months of instrument operation, TOMS did not follow a regular ON/OFF schedule. Originally TOMS was expected to follow a three days ON and one day OFF schedule, similar to SBUV. This schedule was never followed for TOMS. At the beginning of instrument operation, it was ON every day for 17 days before the first turn-off. Subsequently, the instrument was turned off for one day after operating for a number of days without following a regular schedule. The instrument suffered a high voltage failure for six days, June 14-19, 1979. Since June 22, 1979, the instrument has been ON on a full-time basis.

During normal operation there are usually 13 to 14 orbits of TOMS scan data available for each day the instrument is ON. On certain occasions, fewer than this number of data orbits are available due to loss of data in transmission and handling. Even though most of the measurements are taken in the daytime, occasionally there are a few nighttime measurements.

The TOMS inventory classifies each orbit according to the following categories:

- Orbits with daytime data (number of scans ≥ 300).
- Orbits with partial daytime data ($300 >$ number of scans ≥ 20).
- Orbits with nighttime data (number of scans ≥ 100).
- Orbits with no daytime data (number of scans < 20).

Additionally, the date of each orbit is given.

3.3 COLOCATED THIR DATA COVERAGE

The cloud data (on CLT tapes) obtained from the THIR measurements is colocated for the SBUV and TOMS IFOVs. Since THIR is operational both day and night, 100 percent of colocated data coverage is possible for SBUV and TOMS. Approximately 70 percent of the SBUV and TOMS scans have colocated THIR information for the first year and 85% for the second year. THIR data colocation with SBUV/TOMS is less than complete for several reasons:

- The THIR CLT tapes were intended to be generated only for those days when either the SBUV or the TOMS instrument was ON. Because there was some confusion about the actual ON/OFF schedule CLT tapes were not generated for several days when SBUV/TOMS was in operation during the first year. This was corrected for the second year processing, increasing the THIR coverage by approximately 15%.

- Several data handling problems in the CLT program resulted in the loss and/or rejection of about 12% of the THIR data. Modifications have been made in the CLT program which will result in less rejection of data beginning with third year processing.

- Approximately 3% of the THIR data was absent from the CLDT tapes (the input to the CLT generation program). This presumably was due to problems with the THIR instrument.

4. ASSESSMENT OF RUT- S AND -T DATA QUALITY

Both the RUT-S and RUT-T tape data have been subjected to a rigorous set of screening and quality control checks for scan, image location, cloud, terrain height and snow/ice data on a continuous basis. The overall quality of the RUT-S/T data has been found to be excellent. Some minor errors are known to exist on these tapes which will not affect the ozone products derived from the tapes. These errors may in some cases generate noise-like features in the solar flux data which can be easily screened.

4.1 QUALITY CHECKS PERFORMED ON RUT-S AND -T DATA

The RUT-S/T tapes have been subjected to a screening and quality checking procedure. Ephemeris, scan and image location information are checked in the screening procedure When problems exist, the RUT tapes are regenerated with corrected input data.

There has been a continuous improvement in quality and completeness of the data. If the solar zenith angle is missing in more then about 10% of the scans for a day, an attempt is made to recover those missing orbits from the raw instrument data. Beginning with year 2, a data gap check was added. If two or more orbits are missing for one day, an attempt is made to recover the missing data. Sometimes the data could not be recovered, e.g., lost data during telemetry transmission, but by the end of the second year, missing data problems were very infrequent.
Quality checking (QC) of these tapes is done both directly and indirectly. The direct QC procedure is built into the RUT production software system. The indirect QC is done by looking at the intervention products generated from the RUT-S/T tapes to analyze the instrument behavior and to study the solar flux, and by looking at TOMS total ozone pictures produced by using ozone concentrations derived from the RUT-T tape.

The direct QC procedure checks for orbit number, instrument mode of operation, number of scans per data record, day and night coverage, missing solar zenith angles and missing major frames. The snow/ice data is also checked for quality and completeness. Beginning in the latter part of the first year, data were also checked for cloud and terrain height information.

4.2 RUT-S AND -T DATA QUALITY INFORMATION

The overall quality of the RUT-S/T tape data is very good. Due to scheduling errors and software rejection, approximately 30 percent of the first year scans (and 15 percent of the second year scans) do not have colocated THIR cloud data as discussed in Section 3.3. The location accuracy of Nimbus-7 is found to be about 10 km by comparison of earth landmarks using pictures obtained by the Nimbus-7 Coastal Zone Color Scanner (CZCS).

4.3 KNOWN ERRORS IN RUT-S AND RUT-T DATA SETS

Some minor errors have been identified in the RUT-S/T data sets. These are summarized below.

1) Occasional Incorrect Values of the Digital Solar Aspect Sensor (DSAS) Data.
   Two types of errors were encountered with the DSAS data. In some cases, the DSAS azimuth angle was copied incorrectly as the DSAS elevation angle. These cases are listed in Table 4.1 The other kind of error is that the DSAS elevation angle becomes anomalous near the elevation angle of 0^{o}. This second error is present in several cases in the early part of the first year. The solar flux values computed with these erronous angles are far beyond the values expected from instrument noise (1%) and can be easily distinguished from the normal values.

2) Occasional Incorrect Values of THIR Cloud Data
   A temperature calibration error was discovered in the THIR cloud data. This problem was caused by misinterpretation of filled values used for the THIR housing temperature resulting in overestimation of surface and low cloud populations. This error does not impact the ozone products derived from this data since we use the scene reflectance to distinguish surface from low cloud in the ozone processing software (see Ref. 3). This error is present in year 1 data only.

3) Incorrect Values in Trailer Records
   RUT trailer records, which contain processing summary information, are known to contain errors. These errors occur sporadically. This problem is still being investigated.

4) Incorrect Values of SBUV PMT High Voltage

SBUV PMT high voltage values are sometimes incorrect. Among the small number of records we have looked at, a value of 1 volt, instead of the expected value of 916 volts, was frequently observed.

5) Anomalous Instrument Output in the SBUV Continuous Scan

A minor data loss occurs in the SBUV continuous scan measurements. It occurs in both the earth and solar flux observations. Twenty four of the 1200 samples which make up each continuous scan have 0 values. Consecutive occurrences of bad data are separated by 128 samples and each occurrence is exactly eight samples long. Even though this anomaly does not appear to be due to an over-ranging of the output level, a definite correlation has been established with the output level. The anomaly does not occur for output levels less than 11×10^6 counts in gain range 1 of the continuous scan mode.

Table 4.1

Time of Major Frame for Incorrect DSAS Elevation Angle on RUT-S

Orbit Number	Year	Day	GMT of Affected Major Frame (Seconds)
198	1978	311	55466
373		324	25323
398		326	8683
517		334	60811
522		335	5643
565		338	15051
691		347	24572
754		351	72556
802		355	26828
813		356	9148
1007	1979	5	11611
1025		6	37676
1283		25	8172
1400		33	48093
1422		35	12781
1629		50	10413
1643		51	11501
1768		60	15134
1791		61	72494
1949		73	23230
2037		79	54879

Table 4.1 (continued)

Orbit Number	Year	Day	GMT of Affected Major Frame (Seconds)
2101	1979	84	22911
2681		126	19841
2721		129	10721
2750		131	19217
2904		142	31633
4284		242	19542
4325		245	16678
4727		274	21320
4733		274	58856
4737		274	83848

5. RUT-S TAPE FORMATS

The RUT-S tape, a 9-track, unlabeled 1600 BPI tape, is generated by an IBM-360 software system. It is a multiple file binary tape written in fixed block (FB) format which follows the standard Nimbus Observation Processing System (NOPS) tape format structure. The first file on this tape is a special file called the NOPS Standard Header File. It contains the tape identification and processing information. This is followed by a number of Data Files, one data file for each orbit of SBUV data. Each tape contains one week of data. The last file on the tape is known as the Trailer File. Beginning with year 2, a Trailer Documentation File follows the Trailer File (TDF). Each data file contains a variable number of logical data records. The number of data records depends upon the operating mode of the instrument during the orbit. Four types of data record formats are output as a function of instrument operating mode during the orbit. These four operating modes are: Step Scan, Wavelength Calibration, Scan Off/Cage Cam, and Continuous Scan. During the satellite day, the instrument operates either in a step scan or non-step scan mode. Occasional wavelength and electrical calibrations are performed during the satellite night. The detailed description and format of each of the four types of files are given in the following four sections.

5.1 NOPS STANDARD HEADER FILE

The first file on each tape is a standard file common to all magnetic tapes which require interfacing with NOPS. This file contains two identical blocks of information. Each block is 630 characters or bytes long consisting of five 126-character lines written in EBCDIC. Lines 1 and 2 contain similar information known as the NOPS Standard Header Record. This record contains tape identification and processing information. The format of this record is shown in Table 5.1. The NOPS Standard Header Records contained in Lines 1 and 2 carry different generation and destination facility codes, generation date and time and tape copy number. Information Processing Division (IPD) writes Line 1 while generating duplicate tape copies from the master tape. Science and Applications Computing Center (SACC) writes Line 2 while producing the master tape. Lines 3 and 4 are left blank and Line 5 contains information identifying the tape. An example of NOPS Standard Header Record and tape identification information carried on the RUT-S tape is shown below:

NIMBUS-7 NOPS SPEC NO T634111 SQ NO FD00305-1 SBUV SACC TO IPD
START 1978 330 005747 TO 1999 365 002400 GEN 1981 79 001704
SBUV/TOMS RUT-T/CLT MERGED TAPE

5.2 DATA FILES

Data files start from the second file on the tape. There is one data file per data orbit. The number of data files per tape is not fixed. The maximum number of data files on a weekly tape is 97. Since the instrument is not "ON" every day, there are usually less than the maximum number of files on each tape. Each data file consists of a number of logical records. The total number of records in each file varies and the number of records depends on the operating mode during the orbit. Twenty logical records are blocked before they are written on the tape to form a data block (also known as a Physical Record). Each logical record has 180 words or 720 bytes and the blocksize is 14,400 bytes. The first 32-bit word of each record is called a block identifier and contains block, record and file identification information. Its content is shown in Figure 5.1. The record identification code can be used to determine whether the record is located in a data file or a trailer file, and to determine to which instrument operating mode the record corresponds. The first and last records on each data file can be distinguished from the other data records on it.

Table 5.1

Format of NOPS Standard Header Record on RUT-S

Item	Bytes	Character Representation*	Description
1	1-30	$_b$NIMBUS-7$_b$NOPS$_b$SPEC$_b$NO$_b$T634111	NOPS tape specification SBUV.
2	31-37	$_b$SQ$_b$NO$_b$	Sequence number identifier
3	38-39	FD	2 character PDF code for SBUV.
4	40-44	XXXXX	5 digit tape sequence number for each tape.
5	45-46	-X	Tape copy number. Master tape has number 1. For each subsequent copy the number is incremented by 1, i.e. for copy 1 it is 2, etc.
6	47-52	$_b$SBUV$_b$	4 character subsystem identification code for SBUV.
7	53-56	YYYY	4 character tape generation facility identification code. For master tape it is SACC and for a copy it is IPD.
8	57-64	$_b$TO$_b$YYYY	4 character designation facility code, i.e. IPD.

(continued)

*An * in Column 1 indicates that a Trailer Documentation File is present (See Section 5.4).

Table 5.1 (continued)

Item	Bytes	Character Representation*	Description
9	65-87	$_b$START$_b$19XX$_b$DDD$_b$HHMMSS$_b$	Time in year, day, hours, minutes, and seconds corresponding to start of data on tape.
10	88-106	TO$_b$19XX$_b$DDD$_b$HHMMSS$_b$	Time in year, day, hours, minutes, and seconds corresponding to end of data on tape.
11	107-126	GEN$_b$19XX$_b$DDD$_b$HHMMSS$_b$	Time in year, day, hours, minutes, and seconds corresponding to generation time of tape.

*Character 'b' is used to indicate a blank character

Bits:	1-12	13-16	17	18	19-24	25-32
	Block Number	Spare	1 if last block	1 for each block on last file	Record ID	Spare

Record identifications (ID's) of the logical records being read are as follows:

01 - First record on a data file.

10 - All data records in the file for step scan mode.

11 - All data records in the file for wavelength calibration mode.

12 - All data records in the file for cage cam and scan off modes.

13 - All data records in the file for continuous scan mode.

51 - Last record on a data file.

56 - All records in the trailer file.

0 - All dummy records (i.e. padded records).

Figure 5.1 Block Identifier for RUT-S

5.2.1 Format of First Record on Data Files

The first record on a data file contains processing information about the data that follow. The format of this "first record" on a data file is given in Table 5.2. The records that follow are called data records.

5.2.2 Format of Data Records

Four different types of Data Record Formats for RUT-S are written depending on the instrument operating mode during the orbit. The number of data blocks per orbit also varies based on the operating mode. The four different operating modes and the data file structure for each mode are as follows:

Step Scan:	m (a variable number) data blocks per orbit 20 logical records per data block 2 VIP major frames (32 seconds of SBUV data) per logical record
Wavelength Calibration:	Same as step scan mode
Scan Off/Cage Cam:	n (a variable number) data blocks per orbit 20 logical records per data block 1 VIP major frame (16 seconds of SBUV data) per logical record
Continuous Scan:	Same as scan off/cage cam mode

The data record format for SBUV step scan mode is given in Table 5.3. A detailed description of each item listed in this table is given in Table 5.4. The housekeeping information carried in all data records is listed in Table 5.5. The first two columns of this table list corresponding words for VIP major frames 1 and 2. Tables 5.6 thru 5.11 contain the data record formats and detailed descriptions for the Wavelength Calibration, Scan Off/Cage Cam and Continuous Scan modes.

5.2.3 Format of Last Record on Data Files

The record which is written after the last data record in a data block is known as the "last record." This record contains a processing information summary about the data preceding it. The format of this record is given in Table 5.12. This record is repeated until the fixed blocksize of 14400 bytes is reached. The following data block is filled with 20 "last records" to build a trailer block. A "last record" can be identified by checking the Record ID in the Block Identifier shown in Figure 5.1 (bits 19-24 are set such that Record ID = 51). The Logical Sequence Number is set to be a negative integer.

5.3 TRAILER FILE

This is the last file (for year 1) or second last file (beginning with year 2) on the tape and contains only one data block. The data block is made up of 20 logical records, each 720 bytes long. It marks the end of the data on the tape. The Block identifier for every record contains the following:

Block Number (bits 1-12)	= 1
Bit 18	= 1
Record ID (bits 19-24)	= 56

Also the Logical Sequence Number is set to minus one for every record. The rest of the contents of this file can be ignored by the user.

5.4 TRAILER DOCUMENTATION FILE

The Trailer Documentation File is the last file on each volume (tape). It is written in EBCDIC and is used to identify the geneology of each tape. Its structure is the same as the standard header and contains a collection of standard headers (non-duplicated) from all input tapes (not just the input tapes of the computer run that actually created this tape) that were used to produce this tape. The Trailer Documentation File only exists for tapes with an * in the first byte (character) of the NOPS Standard Header File. The TDF is not found on year 1 tapes.

The first record identifies this as the Trailer Documentation File

Chars. 1-10: **********

11-126: NOPS TRAILER DOCUMENTATION FILE FOR TAPE PRODUCT T (SPEC NO. (6 digit)) GENERATED ON DDDHHMM.

The second physical record will be a repeat of the Standard Header File for the current tape with the provision that data referring to end time are correct. Following physical records contain the historical standard header records from the various input tapes.

Table 5.2*

Format of First Record on RUT-S Data Files

Word	Byte 1	Byte 2	Byte 3	Byte 4
	Description			
1	Block identifier (Figure 5.1)			
2	Orbit number at word 8		Day of first good sample	
3	Logical sequence number (1 for this record)		File number	
4-7	Day and date of job run (R*8 EBCDIC), e.g. $TUE_b18_bOCT_b78$ (twice)			
8	GMT time of first good data sample (in seconds of the day)			
9	Subsatellite latitude at word 8		Subsatellite longitude at word 8	
10-11	Program name (R*8 EBCDIC)			
12-13	Program version date (R*8 EBCDIC), e.g. 08/31/78			
14-15	Program version (R*8 EBCDIC), e.g. version 03			
16	GMT time of ascending node (in seconds of the day)			
17	GMT year of first good data sample (last two digits)			
18-180	Spares			

* Word 1, orbit number and logical sequence number are defined as in all other record formats

720 bytes/logical record
Except as noted, all words are in IBM integer format

Table 5.3

Format of RUT-S Data Record in Step Scan Mode

	Byte 1	Byte 2	Byte 3	Byte 4
Word	**Description**			
1	Block identifier			
2	Data orbit number		Day of year at start of scan	
3	Logical sequence number		Data mode	
4	Data flag 1		Data flag 2	
5	Data flag 3		Data flag 4	
6	GMT time of day at start			
7	Subsatellite latitude at start		Subsatellite longitude at start	
8	Altitude at start		Nadir angle	
9	Solar right ascension at start		Solar declination at start	
10	View latitude at start		View longitude at start	
11	Solar zenith angle at start		Solar azimuth angle at start	
12	View angle at start		Azimuth angle at start	
13	DSAS azimuth at start		DSAS elevation	
14-17	Same as words 10-13 but for end **			
18	Monochromator value for gain #1 at 339.9 nm			
19	Monochromator value for gain #2 at 339.9 nm			
20	Monochromator value for gain #3 at 339.9 nm			
21	Recommended monochromator value at 339.9 nm			Gain code
22	Photometer value for 339.9 nm measurement			
23	Reference value for 339.9 nm measurement			
	(continued)			

**except that DSAS data (word 17) is at 8 seconds after start instead of 32 seconds.

Table 5.3 (continued)

	Byte 1	Byte 2	Byte 3	Byte 4
Word	Description			
24-89	Same as words 18-23 for remaining 11 wavelengths			
90	Terrain pressure			
91	Surface category code			
92	Average cloud pressure			
93	Percent cloudiness			
94	Snow/ice thickness		Spare	
95	Surface sample		Mean surface radiance 11.5 μ m	Mean surface radiance 6.7 μ m
96	Low cloud sample population		Mean low cloud radiance 11.5 μ m	Mean low cloud radiance 6.7 μ m
97	Medium cloud sample population		Mean medium cloud radiance 11.5 μ m	Mean medium cloud radiance 6.7 μ m
98	High cloud sample population		Mean high cloud radiance 11.5 μ m	Mean high cloud radiance 6.7 μ m
99	Spare	Low/high radiance 6.7 μ m	Terrain height in meters	
100*	RMS deviation 11.5 μ m surface samples	RMS deviation 11.5 μ m low cloud samples	RMS deviation 11.5 μ m medium cloud samples	RMS deviation 11.5 μ m high cloud samples
101*	RMS deviation 6.7μ m surface samples	RMS deviation 6.7 μ m low cloud samples	RMS deviation 6.7 μ m medium cloud samples	RMS deviation 6.7 μ m high cloud samples
102	Surface category code	Surface to low boundary 11.5 μ m radiance	Low to medium boundary 11.5 μ m radiance	Medium to high boundary 11.5 μ m radiance
	(continued)			

Table 5.3 (continued)

	Byte 1	Byte 2	Byte 3	Byte 4
Word	Description			
103-122	Spare			
123-149	Housekeeping information for first VIP major frame (see Table 5.5)			
150-176	Housekeeping information for second VIP major frame (see Table 5.5)			
177-179	Spare			
180	DQLI flags (4 bits, last 28 bits spare)			

* RMS - root mean square
Blocked at 20 records/block; 720 bytes per logical record.
Blocksize = 14400 bytes
All words are in IBM integer format except, words 1, 4(a,b), 5(a,b) and 180

Table 5.4

Detailed Description of Data Record in Step Scan Mode

Word	Comment
1	See Figure 5.1.
2	(a) Data orbit number based on descending node.
	(b) Day of year at start of scan.
3	(a) Logical sequence number - sequence number of this data record on the tape; starts at 2 and increments each data record.
	(b) Data mode: 0 = INDETERMINATE 1 = STEP SCAN 2 = WAVE CALIBRATION 3 = CAGE CAM 4 = CONTINUOUS SCAN 5 = SCAN OFF
4-5	Data flags for RUT-S tape:
	(a) DATA FLAG 1 X_0 X_1 (b) DATA FLAG 2 X_2 X_3 X_4
	(a) DATA FLAG 3 X_5 X_6 X_7 (b) DATA FLAG 4 X_8 X_9 X_{10} X_{11}
	Definition of X_i: X_0 = attitude source code X_1 = indicator of major frames X_2 = diffuser moving X_3 = SBUV high voltage X_4 = SBUV power enable

(continued)

Table 5.4 (continued)

Word	Comment
4-5	X_5 = mercury lamp*
	X_6 = ECAL
	X_7 = diffuser at SBUV
	X_8 = Cam in sync
	X_9 = chopper-in-sync
	X_{10} = diffuser stowed
	X_{11} = TOMS scanner stowed
	X_i are in hexadecimal and are defined as follows:
	X_0 = 0, means attitude source code not obtained
	X_0 = 4, S/C attitude value was computed by ACS data only.
	X_0 = 5, S/C attitude value was computed by ACS and DSAS data
	X_0 = 6, S/C attitude information unacceptable
	X_0 = 7, no ACS available
	X_1 = 0, if both major frames available for step scan and wavelength calibration modes
	X_1 = 1, major frame 0 only available for step scan and wavelength calibration modes
	X_1 = 2, major frame 1 only available for step scan and wavelength calibration modes
	For X_2 thru X_{11}:
	X_i = 0 means off
	X_i = 1 means on

(continued)

*For the mercury lamp, the warm up time is monitored.

Table 5.4 (continued)

Word	Comment
4-5	X_i = 7 means indeterminate X_5 = 0 means not ON or ON less than one minute X_5 = 1 thru 5 means ON 1 to 5 minutes or more X_5 = 7 indeterminate
6	Greenwich mean time of day (integer seconds) at start of the VIP major frame.
7	(a) Subsatellite geodetic latitude at the start of the major frame expressed as integer radians x 10^4. ($-\pi/2 \leq$ LAT $\leq \pi/2$) Positive latitudes are northward. (b) Subsatellite longitude at the start of the major frame expressed as integer radians x 10^4. ($-\pi \leq$ LONG $\leq \pi$). Positive longitudes are eastward.
8	(a) The spacecraft (S/C) altitude, in integer kilometers, at the start of the major frame. (b) Nadir angle is used to express the S/C attitude error. The nadir angle is the angle between the vectors from the S/C to the local normal and to the instrument FOV at the start of the major frame. This is always a positive angle given in radians x 10^4. ($0 \leq$ nadir angle $\leq \pi$)
9	(a) Solar right ascension (celestial longitude) angle , at the start of the major frame. This angle is measured in the plane of the equator from a fixed inertial axis in space (Vernal Equinox), to a plane normal to the equator (meridian) containing the sun. Eastward from the Vernal Equinox is positive. Expressed in radians x 10^4.($-\pi \leq \alpha \leq \pi$) (b) Solar declination (celestial latitude) angle , at the start of the major frame. This is an angle between the sun and the inertial equator measured in a plane normal to the inertial equator (meridian) containing the sun. North of the equator is positive. Expressed in radians x 10^4. ($-\pi/2 \leq \delta \leq \pi/2$)

(continued)

Note: For angles, missing data is indicated by filling all data field bits with 1's (-32, 767).

Table 5.4 (continued)

Word		Comment
10	(a,b)	View latitude and longitude are the geodetic latitude and longitude at the start of major frame. Expressed in radians x 10^4. $(-\pi/2 \leq \text{LAT} \leq \pi/2)$, $(-\pi \leq \text{LONG} \leq \pi)$. Northward latitudes are positive and eastward longitudes are positive.
11	(a)	Solar zenith angle Z, measured at the FOV between the zenith normal to the tangent plane (horizon) at the FOV and the sun, at the start of the major frame. Expressed in radians x 10^4. $(0 \leq Z \leq \pi)$
	(b)	Solar azimuth angle measured in the tangent plane from a line through the FOV due north to the projection of the sun line into the tangent plane at the start of the major frame. Measured clockwise as seen from the zenith. $(-\pi \leq A \leq \pi)$. Expressed in radians x 10^4.
12	(a)	View angle θ at the start of the major frame is defined as the angle between the local normal (zenith) and the S/C position vectors at the center of the instrument FOV intercept on the Earth's surface. Expressed in radians x 10^4. $(0 \leq \theta \leq \pi/2)$
	(b)	Azimuth angle ϕ at the start of the major frame is defined as the angle between the planes containing the zenith and the S/C, and the zenith and the sun. The angle is measured clockwise as seen from the zenith and expressed in radians x 10^4. $(-\pi \leq \phi \leq \pi)$.
13	(a)	DSAS azimuth angle at the start of major frame is the angle relative to the S/C axes from the DSAS data and ranges from $-\pi$ to π. Expressed in radians x 10^4.

(continued)

Table 5.4 (continued)

Word		Comment
	(b)	DSAS solar elevation angle at the start of major frame is the angle relative to the S/C axes and is obtained from the DSAS subsystem. Values range from $-\pi$ to π. Expressed in radians x 10^4.
14-17		Same as words 10-13 but for end of scan. These values are the angles obtained at the end of major frame except for the DSAS data which are obtained 8 seconds after the start of major frame. (See X_1, major frame indicator, in word 4).
18		Monochromator value for gain number 1 at 339.9 nm is one of the three data values whose data range is in the first (highest) gain range, sampled for 339.9 nm cam position, i.e. first one of the 12 cam position measurements, during one complete step scan cycle.
19		Monochromator value for gain number 2 at 339.9 nm is the second one of the three data values described in word 18 whose data range falls in the second gain range (mid-range).
20		Monochromator value for gain number 3 at 339.9 nm is the last sample of the three data values described in word 18 where data range is in the third gain range (the lowest range).
21	(a)	Recommended monochromator value at 339.9 nm (24 bits). This value is the one recommended for 339.9 nm cam position measurement among three values described above. (Negative if below threshold, i.e. -7777 if gain code = 7).
	(b)	Gain code (8 bits). This indicates which one of the three gain ranges the value described in bits 0-23. = 1 if Gain 1 recommended = 2 if Gain 2 recommended = 3 if Gain 3 recommended

(continued)

Table 5.4 (continued)

Word	Comment
22	Photometer value for 339.9 nm measurement.
23	Reference photodiode value for 339.9 nm measurement (used to monitor the gain of the photomultiplier tube).
24-89	Same as words 18-23 for remaining 11 wavelengths.
90	The FOV terrain pressure interpolated from the National Meteorological Center 2.5^{o} x 2.5^{o} terrain height data set. Expressed in mbars. -7777 indicates fill data.
91	Surface category code is obtained from CLT tape and indicates the type of surface in the ERB (Earth Radiation Budget Experiment) Sub-Target Area (STA) in which this FOV falls. The valid codes are: 1 = LAND 2 = WATER 3 = LAND AND WATER 4 = ICE OR SNOW 5 = ICE AND WATER 6 = ICE/SNOW AND WATER 7 = ICE/SNOW, LAND AND WATER -7777 indicates fill data.
92	Average cloud pressure. The average reflecting surface pressure of low, medium and high clouds at FOV is calculated from the input CLT data. It is expressed in mbars. 1013 mbar is for 0 percent cloudiness. -1111 is the fill data for those FOVs having inversion temperature breakpoints while the percent cloudiness is computed. -7777 is the fill data for all others.
93	Percent cloudiness. The total percentage of low, medium and high clouds at FOV is expressed as %. -7777 is the fill data.
94	Snow and/or ice thickness in tenths of inches. Derived from tapes obtained from the Air Force Global Weather Center, National Climatic Center, Asheville, NC. Note: Words 95-102 are passed directly from words 3-10 of CLT tape.
95	(a) Population of 11.5 μm surface samples. The number of THIR 11.5 μm samples accumulated in the FOV whose radiances are higher than the surface range described in word 102(b).

(continued)

Table 5.4 (continued)

Word		Comment
	(b)	Mean radiance of surface 11.5 μm. The mean of all the 11.5 μm radiances from the samples accumulated in word 95(a). In units of 0.125 w/m^2-ster.
	(c)	Mean radiance of surface 6.7 μm. The mean of all 6.7 μm radiances for samples colocated with those 11.5 μm samples accumulated in word 95(a). In units of 0.015625 w/m^2-ster.
96	(a)	Population of low cloud samples 11.5 μm. The number of THIR 11.5 μm samples accumulated in this FOV whose radiances fall between word 102(b) and word 102(c).
	(b)	Mean radiance of low cloud samples 11.5 μm. Same as word 95(b) except for samples accumulated in word 96(a).
	(c)	Mean radiance of low clouds 6.7 μm. Same as word 95(c) except for samples accumulated in word 96(a).
97	(a)	Population of medium cloud samples 11.5 μm. The number of THIR 11.5 μm samples accumulated in the FOV whose radiances fall between words 102(c) and 102(d).
	(b)	Mean radiance of medium cloud samples 11.5 μm. Same as word 95(b) except for samples accumulated in word 97(a).
	(c)	Mean radiance of medium cloud samples 6.7 μm. Same as word 95(c) except for samples accumulated in word 97(a).
98	(a)	Population of high cloud samples 11.5 μm. The number of THIR 11.5 μm samples accumulated in this FOV whose radiances fall below word 102(c).
	(b)	Mean radiances of high cloud samples 11.5 μm. Same as word 95(b) except for samples accumulated in word 98(a).
	(c)	Mean radiance of high cloud samples 6.7 μm. Same as word 95(c) except for samples accumulated in word 98(a).

(continued)

Table 5.4 (continued)

Word		Comment
99	(a)	Spare. Zeros for word alignment.
	(b)	Cirrus high/low radiance 6.7 μm. The 6.7 μm radiance used to determine the presence of cirrus clouds in the SBUV FOV. In units of 0.015625 w/m^2-ster.
	(c)	The average terrain height equivalent for this FOV expressed in meters.
100	(a)	RMS deviation surface 11.5 μm. The RMS deviation of the 11.5 μm samples averaged in word 95(b). In units of 0.015625 w/m^2-ster.
	(b)	RMS deviation low clouds 11.5 μm. The RMS deviation for word 96(b). Scaled the same as word 100(a).
	(c)	RMS deviation medium clouds 11.5 μm. The RMS deviation for word 97(b). Scaled the same as word 100(a).
	(d)	RMS deviation high clouds 11.5 μm. The RMS deviation for word 98(b). Scaled the same as word 100(a).
101	(a)	RMS deviation surface 6.7 μm. The RMS deviation of the 6.7 μm samples averaged in word 95(c). In units of 0.00392 w/m^2-ster.
	(b)	RMS deviation low clouds 6.7 μm. The RMS deviation for word 96(c). Scaled the same as word 101(a).
	(c)	RMS deviation medium clouds 6.7 μm. The RMS deviation for 97(c). Scaled the same as word 101(a).
	(d)	RMS deviation high clouds 6.7 μm. The RMS deviation for word 98(c). Scaled the same as word 101(a).
102	(a)	Surface category code. The code indicates the type of surface in the ERB-STA in which this FOV falls. The only valid codes are given under word 91.
	(b)	Surface/low cloud radiance. The radiance used to separate the THIR 11.5 μm samples into the lowest histogram level - between surface and low altitude clouds. In units of 0.125 w/m^2-ster.

(continued)

Table 5.4 (continued)

Word	Comment
	(c) Low/medium cloud radiance. The radiance used to separate the THIR 11.5 μm samples into the two mid-level histograms - between low and medium altitude clouds. In units of 0.225 w/m^2-ster.
	(d) Medium/high cloud radiance 11.5 μm. The radiance used to separate the THIR 11.5 μm samples into the highest histogram level - between high and medium altitude clouds. In units of 0.125 w/m^2-ster.
103-122	Spares
123-149	Housekeeping information for first major frame (See Table 5.5).
150-176	Housekeeping information for second major frame (See Table 5.5).
177-179	Spares
180	DQLI (Data Quality Loss Interval) flags for digital A status (4 bits): Bit 1 Off/On digital A (minor frame 0) Bits 1-30 Bit 2 Off/On digital A (minor frame 0) Bits 31-47 Bit 3 Off/On digital A (minor frame 40) Bits 1-30 Bit 4 Off/On digital A (minor frame 40) Bits 31-47 Off = No DQLI; On = DQLI Spares (last 28 bits).

Table 5.5

Format of Housekeeping Information on RUT-S Data Record

Word (1st VIP)	Word (2nd VIP)	Byte 1	Byte 2	Byte 3	Byte 4
		Description			
123	150	S/C status number 1			
124	151				
125	152	S/C status number 2			
126	153				
127	154	S/C status number 3			
128	155				
129	156	Chopper motor temperature (°C)		Cam motor temperature (°C)	
130	157	SBUV diffuser motor temperature (°C)		SBUV diffuser plate stow (°C)	
131	158	-6.375V		Signal ground (TV)	
132	159	ELM temperature (°C)		SBUV calibration lamp temperature (°C)	
133	160	SBUV AC supply (V)		ELM AC supply (V)	
134	161	SBUV housing temperature (°C)		Spare	
135	162	ELM signal ground		ELM 10V bias	
136	163	ELM 12V		ELM SBUV chopper motor current	
137	164	ELM SBUV housekeeping temperature (°C)		ELM SBUV wall gradient (°C)	
138	165	SBUV signal ground (TV)		SBUV +10V (TV)	
139	166	SBUV +12V (TV)		SBUV +60V (TV)	
140	167	SBUV reference photometer temperature (°C)		SBUV photometer temperature (°C)	
141	168	SBUV electronic temperature (°C)		SBUV photomultiplier tube temperature (°C)	

(continued)

Table 5.5 (continued)

Word (1st VIP)	Word (2nd VIP)	Byte 1	Byte 2	Byte 3	Byte 4
		Description			
142	169	SBUV high voltage monitor (TV)		Spare	
143	170	Digital B sample 1			
144	171	Digital B sample 2			
145	172	Digital B sample 3			
146	173	Digital A major frame 0 sample 2			
147	174	Digital A major frame 0 sample 2			
148	175	Digital A major frame 40 sample 1			
149	176	Ditital A major frame 40 sample 2			

°C = degrees centigrade
V = volts
TV = telemetry volts
ELM = electronic module

Table 5.6*

Format of RUT-S Data Record in Wavelength Calibration Mode

	Byte 1	Byte 2	Byte 3	Byte 4
Word	Description			
1	Block identifier			
2	Data orbit number		Day of year at start of scan	
3	Logical sequence number		Data mode	
4	Data flag 1		Data flag 2	
5	Data flag 3		Data flag 4	
6	GMT time of day at start			
7	Subsatellite latitude at start		Subsatellite longitude at start	
8	Altitude at start		Nadir angle	
9	Solar right ascension at start		Solar declination at start	
10	View latitude at start		View longitude at start	
11	Solar zenith angle at start		Solar azimuth angle at start	
12	View angle at start		Azimuth angle at start	
13	DSAS azimuth at start		DSAS elevation	
14-17	Same as words 10-13 but for end **			
18	Monochromator value for gain number 1 at 254.7 nm			
19	Monochromator value for gain number 2 at 254.7 nm			
20	Monochromator value for gain number 3 at 254.7 nm			
21	Recommended monochromator value at 254.7 nm			Gain code
22	Photometer value for 254.7 nm measurement			
23	Reference value for 254.7 nm measurement			
24-47	Same as words 18-23 for remaining four wavelengths			
48-122	Spares			
(continued)				

**except that DSAS data (word 17) is at 8 seconds after start, instead of 32 seconds

Table 5.6 (continued)

	Byte 1	Byte 2	Byte 3	Byte 4
Word	Description			
123-149	Housekeeping information for first major frame (see Table 5.5)			
150-176	Housekeeping information for second major frame (see Table 5.5)			
177-179	Spares			
180	DQLI flags (4 bits, last 28 bits spare)			

* Blocked at 20 logical records/block
720 bytes/records
blocksize = 14400 bytes
All words are in IBM integer format except words 1, 4(a,b), 5(a,b), and 180

Table 5.7

Detailed Description of RUT-S Data Record in Wavelength Calibration Mode

Word	Comment
1-17	Same as words 1-17 for step scan
18	Monochromator value for gain number 1 at 254.7 nm
19	Monochromator value for gain number 2 at 254.7 nm
20	Monochromator value for gain number 3 at 254.7 nm
21	Recommended monochromator value at 254.7 nm (Negative if below threshold, i.e. -7777 if gain code = 7). Associated gain code (8 bits, Logical * 1) = 1 if gain number 1 recommended = 2 if gain number 2 recommended = 3 if gain number 3 recommended = 7 if no recommendation
22	Photometer value for 254.7 nm measurement
23	Reference photodiode value for 254.7 nm measurement
24-47	Same as words 18-23 for remaining four wavelengths
48-122	Spares
123-180	Same as words 123-180 for step scan mode

Table 5.8

Format of RUT-S Data Record in Scan Off and Cage Cam Modes

	Byte 1	Byte 2	Byte 3	Byte 4
Word	Description			
1	Block identifier			
2	Data orbit number		Day of year at start of scan	
3	Logical sequence number		Data mode	
4	Data flag 1		Data flag 2	
5	Data flag 3		Data flag 4	
6	GMT time of day at start			
7	Subsatellite latitude at start		Subsatellite longitude at start	
8	Altitude at start		Nadir angle	
9	Solar right ascension at start		Solar declination at start	
10	View latitude at start		View longitude at start	
11	Solar zenith angle at start		Solar azimuth angle at start	
12	View angle at start		Azimuth angle at start	
13	DSAS azimuth at start		DSAS elevation	
14-17	Same as words 10-13 but for end **			
18	Monochromator value for gain number 1, sample number 1			
19	Monochromator value for gain number 2, sample number 1			
20	Monochromator value for gain number 3, sample number 1			
21	Recommended monochromator value sample number 1			Gain code
22	Photometer value for sample number 1 measurement			
23	Reference value for sample number 1 measurement			
24-113	Same as words 18-23 for remaining samples numbers 2 to 16			
114-149	Spares			
	(continued)			

**except that DSAS data (word 17) is at 8 seconds after start instead of 16 seconds

Table 5.8 (continued)

Word	Byte 1	Byte 2	Byte 3	Byte 4
	Description			
150-176	Housekeeping information (see Table 5.5)			
177	Major frame number*			
178	Calibration range select code			
179	Spare			
180	DQLI flags (4 bits, last 28 bits spare)			

* Some products need major frame number to process ECAL.

Blocked at 20 logical records/block

720 bytes/records

blocksize = 14400 bytes

All words are in IBM integer format except words 1, 4(a,b), 5(a,b) and 180.

Table 5.9

Detailed Description of RUT-S Data Record in Scan Off and Cage Cam Modes

Word	Comment
1-17	Same as words 1-17 for step scan
18	Monochromator value for gain number 1 sample number 1
19	Monochromator value for gain number 2 sample number 1
20	Monochromator value for gain number 3 sample number 1
21	(a) Recommended monochromator value sample number 1 (Negative if below threshold, i.e. -7777 if gain code number 7) (b) Associated gain code (8 bits) Number 1 if gain number 1 recommended Number 2 if gain number 2 recommended Number 3 if gain number 3 recommended Number 7 if no recommendation
22	Photometer value for sample number 1 measurement
23	Reference value for sample number 1 measurement
24-113	Same as words 18-23 for remaining samples
114-149	Spares
150-176	Housekeeping information (see Table 5.5)
177	Major frame number
178	Calibration range select code. There are 20 pre-determined valid intervals (ranges) for screening the counts obtained for each level of electronic calibration for each of the three gain ranges, photometer and reference (i.e. 4 levels * 5 instrument measurements at each level) The select code specifies which interval is to be used to screen for bad counts. The select code must correspond to Frame # as follows: Select code = 0 for frame 0 & 1 Select code = 2 for frame 2 & 3 Select code = 1 for frame 4 & 5 Select code = 3 for frame 6 & 7
179-180	Same as words 179-180 for step scan

Table 5.10*

Format of RUT-S Data Record in Continuous Scan Mode

	Byte 1	Byte 2	Byte 3	Byte 4
Word	Description			
1	Block identifier			
2	Data orbit number		Day of year at start of scan	
3	Logical sequence number		Data mode	
4	Data flag 1		Data flag 2	
5	Data flag 3		Data flag 4	
6	GMT time of day at start			
7	Subsatellite latitude at start		Subsatellite longitude at start	
8	Altitude at start		Nadir angle	
9	Solar right ascension at start		Solar declination at start	
10	View latitude at start		View longitude at start	
11	Solar zenith angle at start		Solar azimuth angle at start	
12	View angle at start		Azimuth angle at start	
13	DSAS azimuth at start		DSAS elevation	
14-17	Same as words 10-13 but for end **			
18	Data sample number 1		Data sample number 2	
19-117	Data samples number 3 to 200			
118-133	Photometer samples 1-16			
134-149	Reference samples 1-16			
150-176	Housekeeping information			
177	Major Frame No.			
178-179	Spares			
180	DQLI flags (4 bits, last 28 bits spare.)			

* Blocked at 20 records/block
720 bytes/records
blocksize = 14400 bytes
All words are in IBM integer format except words 1, 4(a,b), 5(a,b) and 180.

**DSAS data (word 17) is at 8 seconds after start instead of 16 seconds.

Table 5.11

Detailed Description of RUT-S Data Record in Continuous Scan Mode

Word	Comment
1-17	Same as words 1-17 for step scan
18-117	Data samples number 1 to 200. These samples are the monochromator channel output obtained in 80 milliseconds each during one major frame (16 sec.) The measurements are the photometric response obtained at every 0.2 nm increment, beginning at 160.0 nm at the start of the scan cycle It will continue to output 1200 samples until it completes the cycle at 400.0 nm. A complete cycle takes 7 major frames; however, the first major frame is not used for sampling.
118-133	Photometer samples number 1 to 16
134-149	Reference samples number 1 to 16
150-180	Same as words 150-180 for step scan except that 177 is Major Frame No.

Table 5.12*

Format of Last Record on RUT-S Data Files

	Byte 1	Byte 2	Byte 3	Byte 4
Word	**Description**			
1	Block identifier			
2	Data orbit number		Day of year at end of file	
3	Negative logical sequence number		File number	
4-6	Spares			
7	GMT time of day at end of file (seconds)			
8	Subsatellite latitute at end		Subsatellite longitude at end	
9	Number of UFO records read			
10	Number of RUT-S physical records written (for orbit)			
11	Number of records rejected for I/O error			
12	Number of SBUV frames with bad power			
13	Number of SBUV frames with mismatched frame number			
14	Number of SBUV frames rejected for mode error			
15	Number of SBUV frames with chopper-out-of-sync.			
16	Number of SBUV frames with cam-out-of-sync.			
17	Number of SBUV frames with diffuser moving			
18	Number of SBUV step-scan frames			
19	Number of SBUV continuous scan frames			
20	Number of SBUV cage cam frames			
21	Number of SBUV scan off frames			
22	Number of SBUV cage cam/scan off frames			
	(continued)			

Table 5.12 (continued)

	Byte 1	Byte 2	Byte 3	Byte 4
Word	Description			
23	Number of SBUV wavelength calibration frames			
24	Number of SBUV frames with ECAL			
25	Number of frames with diffuser at SBUV			
26	Number of frames with mercury lamp on			
27	Number of negative values for gain 1			
28	Number of negative values for gain 2			
29	Number of negative values for gain 3			
30	Number of overrange values for gain 1			
31	Number of overrange values for gain 2			
32	Number of overrange values for gain 3			
33	Number of data points for SBUV chopper motor temperature			
34	Minimum value for word 33			
35	Maximum value for word 33			
36	Average value for word 33			
37	Standard deviation for word 33			
38-42	As 33-37 for SBUV cam motor temperature			
43-47	As 33-37 for SBUV diffuser motor temperature			
48-52	As 33-37 for SBUV diffuser plate stow temperature			
53-57	As 33-37 for ELM temperature			
58-62	As 33-37 for SBUV calibration lamp temperature			
63-67	As 33-37 for SBUV housing temperature			
68-72	As 33-37 for -6.37V thermistor bias			
73-77	As 33-37 for signal ground			
78-82	As 33-37 for SBUV AC supply voltage			
83-87	As 33-37 for ELM AC supply voltage			
88-92	As 33-37 for ELM signal ground			
93-97	As 33-37 for ELM +10V thermistor bias			
	(continued)			

Table 5.12 (continued)

	Byte 1	Byte 2	Byte 3	Byte 4
Word	Description			
98-102	As 33-37 for ELM +12V supply			
103-107	As 33-37 for ELM SBUV chopper motor current			
108-112	As 33-37 for ELM SBUV housing temperature			
113-117	As 33-37 for ELM SBUV wall gradient			
118-122	As 33-37 for SBUV signal ground			
123-127	As 33-37 for SBUV +10V thermistor bias			
128-132	As 33-37 for SBUV +12V supply			
133-137	As 33-37 for SBUV +60 supply			
138-142	As 33-37 for SBUV reference photodiode temperature			
143-147	As 33-37 for SBUV photometer photodiode temperature			
148-152	As 33-37 for SBUV electrometer temperature			
153-157	As 33-37 for SBUV PMT temperature			
158-162	As 33-37 for SBUV high voltage monitor			
163-180	Spare			

* Words 2(a,b), 3(a,b), 8(a,b) are I*2 integers, and words 7, 9-32 are I*4 integers.
Rest of the words are in R*4 floating point format.
720 bytes/record.

6. RUT-T TAPE FORMATS

The RUT-T tape is generated by the same IBM 360 software which generates the RUT-S tape. It is a 9-track, unlabelled 1600 BPI, multiple file binary tape with fixed block (FB) format following the standard NOPS tape format structure. The first file is a NOPS Standard Header File, followed by a number of Data Files, and finally a Trailer File. Beginning with year 2, the Trailer File is followed by a Trailer Documentation File. Normally, one to three tapes are porduced for one week of data. There is one data file per orbit with a maximum of 97 data files per week written on one to three tapes. Each data file contains a variable number of data records depending on the instrument operation. A detailed description and format of each of the four files mentioned earlier are given in Sections 6.1 - 6.4.

6.1 NOPS STANDARD HEADER FILE

Table 6.1 shows the NOPS Standard Header Record tape format which corresponds to a format similar to the RUT-S, Section 5, Table 5.1. An example of NOPS Standard Header Record and tape identification information printed by the SBUV/TOMS subsystem analyst is as follows:

NIMBUS-7 NOPS SPEC NO T634121 SQ NO FJ00336-2 TOMS SACC TO IPD
START 1978 304 0 10 110 TO 1999 365 002400 GEN 1981 80 132020
SBUV/TOMS RUT-T/CLT MERGED TAPE

6.2 DATA FILES

Data files start from the second file on the tape with one data file per data orbit. The number of data files per week depends on the instrument operation and the number of data orbits per week. If TOMS is on continuously during one week, there will be 97 data files for that particular week. The instrument has been operational every day since June 19, 1979. However, prior to this date, the instrument was turned off occasionally for a day at a time after being operational for a few days. Therefore, the number of data files per week was less than the maximum number prior to June 19, 1979.

Table 6.1

Format of NOPS Standard Header Record on RUT-T

Item	Bytes	Character Representation*	Description
1	1-30	$_b$NIMBUS-7$_b$NOPS$_b$SPEC$_b$NO$_b$T634121	NOPS specification number for TOMS.
2	31-37	$_b$SQ$_b$NO$_b$	Sequence number identifier.
3	38-39	FJ	Two character PDF code for TOMS.
4	40-44	XXXXX	5 digit tape sequence number for each tape.
5	45-46	-X	Tape copy number. Master tape has number 1. For each subsequent copy, the number is incremented by 1, i.e. for copy 1 it is 2.
6	47-52	$_b$TOMS$_b$	4 character subsystem identification code for TOMS.
7	53-56	YYYY	4 character tape generation facility identification code. For master tape it is SACC and for a copy it is IPD.
8	57-64	$_b$TO$_b$YYYY	4 character tape designation facility code, i.e. IPD.
9	65-87	$_b$START$_b$19XX$_b$DDD$_b$HHMMSS$_b$	Time in year, day, hours, minutes, and seconds corresponding to start of data on tape.

(continued)

*An * in column 1 indicates that a Trailer Documentation File is present (See Section 5.4).

Table 6.1 (continued)

Item	Bytes	Character Representation*	Description
10	88-106	$TO_b19XX_bDDD_bHHMMSS_b$	Time in year, day, hours, minutes, and seconds corresponding to end of data on tape.
11	107-126	$GEN_b19XX_bDDD_bHHMMSS_b$	Time in year, day, hours, minutes, and seconds corresponding to generation time of tape.

*Character 'b' is used to indicate a blank character.

Each file consists of a number of logical records the total number of which varies and depends on instrument operation during the orbit. Six logical records are blocked before they are written on the tape to form a data block (also known as a physical record). Each logical record has 666 words or 2664 bytes and the blocksize is 15,984 bytes. The first 32-bit word of each record is a block identifier and it contains block, record and file identification information. The information content of the RUT-T block identifier is shown in Figure 6.1. The record identification code can be used to identify whether the record is first or last on a file and if it is on a data file or a trailer file. The instrument operating information is also contained in this code. The first and last records on a file can be distinguished from the data records because the content of each one is different.

6.2.1 Format of First Record on Data Files

The first record on a data file contains processing information about the data that follow. The format of this "first record" is given in Table 6.2. It is followed by a number of data records.

6.2.2 Format of Data Records

Each data record contains TOMS data for one VIP major frame or 16 seconds. This corresponds to two scans because every TOMS scan is 8 seconds long. Table 6.3 shows the RUT-T data record format; a detailed description of each item in this table is given in Table 6.4. The housekeeping data format on the data record is given in Table 6.5.

6.2.3 Format of Last Record on Data Files

The "last record" is written after the last data record in a data block. This record contains the processing information summary about the data preceding it. The "last record" format is given in Table 6.6. This record is repeated until the blocksize of 15,984 bytes is reached. The data block immediately following this block is called a trailer block and consists of six "last records". The RUT-T "last record" can be identified by checking the Record ID in the block identifier shown in Figure 6.1 (bits 19-24 are set so that Record ID = 52), and checking the logical sequence number (which is set to be a negative integer).

6.3 TRAILER FILE

This is the last file (for year 1) or second last file (beginning with year 2) on the RUT-T tape and contains only one data block. The data block consists of six logical records, each 2664 bytes long. The purpose of this file is to mark the end of data on the tape. The block identifier for each record contains the following:

Block Number (bits 1-12)	=	1
Bit 18	=	1
Record ID (bits 19-24)	=	57

Also the logical sequence number is set to be minus one for every record. The remaining contents of this file can be ignored by the user.

6.4 TRAILER DOCUMENTATION FILE

The Trailer Documentation File is the last file on each volume (tape). It is written in EBCDIC and is used to identify the geneology of each tape. Its structure is the same as the standard header and contains a collection of standard headers (non-duplicated) from all input tapes (not just the input tapes of the computer run that actually created this tape) that were used to produce this tape. The Trailer Documentation File only exists for tapes with an * in the first byte (character) of the NOPS Standard Header File. The TDF is not found on year 1 tapes.

The first record identifies this as the Trailer Documentation File

Chars. 1-10 **********

11-126: NOPS TRAILER DOCUMENTATION FILE FOR TAPE PRODUCT (Spec No. (6 digit)) GENERATED ON DDDHHMM.

The second physical record will be a repeat of the Standard Header File for the current tape with the provision that data referring to end time are correct. Following physical records contain the historical standard header records from the various input tapes.

Bits:	1-12	13-16	17	18	19-24	25-32
	Block Number	Spare	1 if last block	1 for each block on last file	Record ID	Spare

Record identifications (ID's) of the logical records being read are as follows:

02 - First record on a data file.

09 - Scan off.

14 - Normal scan.

15 - Single step scan.

16 - Scanner stowed.

17 - Scanner at diffuser.

52 - Last record on a data file.

57 - All records on a trailer file.

Figure 6.1 Block Identifer for RUT-T

Table 6.2*

Format of First Record on RUT-T Data Files

	Byte 1	Byte 2	Byte 3	Byte 4
Word	Description			
1	Block identifier (Figure 6.1)			
2	Orbit number at word 8		Day of first good sample	
3	Logical sequence number (1 for this record)		Spare	
4-7	Day and date of job run (R*8 EBCDIC), e.g. $TUE_b18_bOCT_b78$ (twice)			
8	GMT time of first good data sample (in seconds of the day)			
9	Subsatellite latitude at word 8		Subsatellite longitude at word 8	
10-11	Program name (R*8 EBCDIC)			
12-13	Program version date (R*8 EBCDIC), e.g. 08/31/78			
14-15	Program version date (R*8 EBCDIC), e.g. version 03			
16	GMT time of ascending node (in seconds of the day)			
17	GMT year of first good data sample (last two digits)			
18-666	Spares			

* Word 1, Orbit number and logical sequence number are defined as in all other record formats

All words are in IBM integer format except as noted.

2664 bytes/logical record

Table 6.3**

Format of RUT-T Data Records

Word	Byte 1	Byte 2	Byte 3	Byte 4
	Description			
1	Block identifier (Figure 6.1)			
2	Data orbit number		Day of year at start	
3	Logical sequence number		First 12 bits spare, last 4 bits DQLI flags	
4	Data mode scan 1		Data mode scan 2	
5	Data flag 1		Data flag 2	
6	Data flag 3		Data flag 4	
7	GMT time of day at start			
8	Subsatellite latitude at start		Subsatellite longitude at start	
9	Altitude at start		Nadir angle at start	
10	Solar right ascension at start		Solar declination at start	
11	DSAS azimuth at start		DSAS elevation at start	
12	DSAS azimuth at start + 8 seconds		DSAS elevation at start + 8 seconds	
13	View latitude scene 1		View longitude scene 1	
14	Solar zenith angle scene 1		View angle scene 1	
15	Azimuth angle scene 1		Screening flag	Scanner position
*16	380.0 nm value scene 1		360.0 nm value scene 1	
*17	339.8 nm value scene 1		331.3 nm value scene 1	
*18	317.5 nm value scene 1		312.5 nm value scene 1	
19	Terrain pressure		Surface category code	
20	Average cloud pressure		Percent cloudiness	
21	Snow/ice thickness		Spare	
	(continued)			

Table 6.3 (continued)

	Byte 1	Byte 2	Byte 3	Byte 4
Word	Description			
22-327	Same as 13-21 for scene 2-35			
328-642	Same as 13-327 for scan 2			
643-665	Housekeeping information			
666	Major frame counter		ECAL counter	

** Blocked at 6 records/block, 2664 bytes/record
Block size = 15,984 bytes
All words are in IBM integer format except as noted in Table 6.4.

* For wavelength calibration, the values in words 16-18 will be:

297.5 nm	297.0 nm
296.5 nm	296.0 nm
Spare	Spare

Table 6.4

Detailed Description of RUT-T Data Record

Word		Comment
2	(a)	Data orbit number based on descending node.
	(b)	Day of year at start of scan.
3	(a)	Logical sequence number - sequence number of this data record on the tape; starts at 2 and increments each data record. 1 = HEADER and negative number = TRAILER
	(b)	Spares (12 bits) DQLI flags (4 bits) for digital A status bits: Bit 29 Off/On digital A (Minor Frame 0) Bits 1-30 Bit 30 Off/On digital A (Minor Frame 0) Bits 31-47 Bit 31 Off/On digital A (Minor Frame 40) Bits 1-30 Bit 32 Off/On digital A (Minor Frame 40) Bits 31-47 Off = No DQLI On = DQLI
4	(a)	Data mode scan 1
	(b)	Data mode scan 2 (both flags identical): 0 = INDETERMINATE 1 = SCAN OFF 2 = SINGLE STEP 3 = NORMAL SCAN 4 = STOWED 5 = VIEW DIFFUSER

(continued)

Table 6.4 (continued)

Word	Comment
5-6	Data flags for RUT-T tape:
	(a) DATA FLAG 1: X_0 X_1 X_2 (b) DATA FLAG 2: X_3 X_4 X_5
	(a) DATA FLAG 3: X_6 X_7 X_8 (b) DATA FLAG 4: X_9 X_{10} X_{11} X_{12}
5-6	Definition of X_i:
	X_0 = attitude source code
	X_1 = scanner in sync
	X_2 = scanner in sync
	X_3 = diffuser moving
	X_4 = TOMS high voltage
	X_5 = TOMS power enable
	X_6 = mercury lamp*
	X_7 = ECAL
	X_8 = diffuser at TOMS
	X_9 = TOMS scanner stowed
	X_{10} = diffuser stowed
	X_{11} = wavelength calibration
	X_{12} = chopper-in-sync
	X_i are in hexadecimal and are defined as follows:
	For X_0:
	0 = attitude source code not obtained
	4 = S/C attitude value was computed by ACS data only

*For the mercury lamp, the warm up time is monitored.

Table 6.4 (continued)

Word	Comment
5–6	5 = S/C attitude value was computed by ACS and DSAS data
	6 = S/C attitude information unacceptable
	7 = no ACS available
	For X_1 through X_{12}; except X_5:
	0 = no
	1 = yes
	7 = indeterminate
	For X_5:
	0 = 0 means not on or on less than one minute
	1-5 = on 1 to 5 minutes or more
	7 = indeterminate
7	Greenwich mean time at start of scan (in seconds).
8	(a) Subsatellite geodetic latitude at the start of the major frame (scan 1) expressed as integer radians x 10^4. ($-\pi/2 \leq$ LAT $\leq \pi/2$). Positive latitudes are northward.
	(b) Subsatellite longitude at the start of the major frame expressed as integer radians x 10^4. ($-\pi \leq$ LONG $\leq \pi$). Positive longitudes are eastward.
9	(a) The spacecraft altitude, in integer kilometers, at the start of the major frame.
	(b) Nadir angle is used to express the spacecraft's attitude error. The nadir angle is the angle between the vectors from the S/C to the local normal and from the S/C to the FOV. It is expressed in radians x 10^4. ($0 \leq$ nadir angle $\leq \pi$).

(continued)

Note: For angles, missing data is indicated by filling all data field bits with 1's (-32, 767).

Table 6.4 (continued)

Word		Comment
10	(a)	Solar right ascension (celestial longitude) angle α, at the start of the major frame. This angle is measured in the plane of the equator from a fixed intertial axis in space (Vernal Equinox), to a plane normal to the equator (meridian) containing the sun. Eastward from the Vernal Equinox is positive. Expressed in radians x 10^4. $(-\pi \leq \alpha \leq \pi)$
	(b)	Solar declination (celestial latitude) angle δ, at the start of the major frame. This is an angle between the sun and the inertial equator measured in a plane normal to the inertial equator (meridian) containing the sun. North of the equator is positive. Expressed in radians x 10^4. $(-\pi/2 \leq \delta \leq \pi/2)$
11	(a)	DSAS azimuth at start of major frame is the angle relative to the S/C axes from the DSAS data and ranges from $-\pi$ to π. Expressed in radians x 10^4.
	(b)	DSAS elevation at start of major frame is the angle relative to the S/C axes obtained from the DSAS subsystem. Values range from $-\pi$ to π. Expressed in radians x 10^4.
12	(a)	DSAS azimuth 8 seconds after start of major frame. Expressed in radians x 10^4.
	(b)	DSAS elevation at 8 seconds after start of major frame. Expressed in radians x 10^4.
13	(a,b)	View latitude and longitude scene 1, scan 1 (two 16 bit words): - The geodetic latitude and longitude at the midpoint of the TOMS scene 1 field of view, expressed as radians x 10^4. $(-\pi/2 \leq \text{LAT} \leq \pi/2)$, $(-\pi \leq \text{LONG} \leq \pi)$. Positive latitudes are north and positive longitudes are east.
14	(a)	Solar zenith angle Z, for scene 1, the angle measured at the FOV between the zenith normal to the tangent plane (horizon) at the FOV and the sun. Expressed in radians x 10^4. $(0 \leq Z \leq \pi)$
	(b)	View angle θ defined as the angle between the local normal (zenith) and the S/C position vector at the center of the instrument FOV intercept on the Earth's surface. Expressed in radians x 10^4. $(0 \leq \theta \leq \pi/2)$.

(continued)

Table 6.4 (continued)

Word		Comment
15	(a)	Azimuth angle ϕ is the angle between the planes containing the zenith and the S/C, and the zenith and the sun. It is measured clockwise as seen from the zenith. ($-\pi \leq \phi \leq \pi$). Expressed in radians x 10^4.
	(b)	Screening flag = 0 if no 3-bit exponent in the scene was bad; = X where X is the number of times a bad exponent was encountered in unpacking one scene. Occupies byte #3. (Logical *1)
	(c)	Scanner position: integer number from 0 to 63 giving the TOMS scanner encoder output. A table relating the encoder output to the actual position of the TOMS scanner is given in Appendix C. If a DQLI occurred during transmission of the scanner position, the scanner will be set to FF in hexadecimal. Occupies byte #4 (Logical *1)
16	(a)	Scene 1, 380.0 nm value or 297.5 nm wavelength calibration value. A 16 bit word giving the instrument output for the 380.0 nm measurement in the normal scan mode, or the 297.5 nm measurement in the wavelength calibration mode.

16 15 14 13	12 11 10 9 8 7 6	5 4 3	2 1
SPARES	MANTISSA	EXP	GAIN CODE

Word		Comment
	(b)	Scene 1, 360.0 nm value or 297.0 nm value when in wavelength calibration mode. Same as previously shown but for different wavelengths.
17	(a)	Scene 1, 339.9 nm value or 296.5 nm value when in wavelength calibration mode. Same as word 16(a) but for different wavelengths.
	(b)	Scene 1, 331.3 nm value or 296.0 nm value when in wavelength calibration mode. Same as word 16(a) but for different wavelengths.
18	(a)	Scene 1, 317.5 nm value or spare. Same as word 16(a) but for different wavelengths.
	(b)	Scene 1, 312.5 nm value or spare. Same as word 16(a) but for different wavelengths.

(continued)

Note: For angles, missing data is indicated by filling all data field bits with 1's (-32, 767).

Table 6.4 (continued)

Word		Comment
19	(a)	The FOV terrain pressure interpolated from the National Meteorological Center 2.5° x 2.5° terrain height data set. Expressed in mbar. -7777 indicates fill data.
	(b)	Surface category code is obtained from CLT tape and indicates the type of surface in the ERB-STA in which this FOV falls. The valid codes are: 1 = LAND 2 = WATER 3 = LAND AND WATER 4 = ICE OR SNOW 5 = ICE AND WATER 6 = ICE/SNOW AND WATER 7 = ICE/SNOW, LAND AND WATER -7777 indicates fill data.
20	(a)	Average cloud pressure. The average reflecting surface pressure of low, medium and high clouds at the FOV as determined from THIR data, expressed in mbar. 1013 mbar is for 0 percent cloudiness. -1111 is the fill data for those FOVs having inversion temperature breakpoints while the percent cloudiness is computed. -7777 is the fill data for all others.
	(b)	Percent cloudiness. The total percentage of low, medium and high clouds at the FOV as determined from THIR data, expressed as %. -7777 is the fill data.
21		Snow and/or ice thickness in tenths of inches derived from tapes obtained from the Air Force Global Weather Center, National Climatic Center, Asheville, NC.
22-327		Same as words 13 to 21 for scenes 2 to 35.
328-642		Same as words 13 to 327 for scan 2.
643-665		Housekeeping information (see Table 6.5).
666	(a)	Major frame counter from digital A status bits 27, 28 and 29. Set to -1 if a DQLI occurred.
	(b)	ECAL counter from Digital A status bits 43, 44 and 45. Set to -1 if a DQLI occurred.

Table 6.5*

Format of Housekeeping Information on RUT-T Data Records

	Byte 1	Byte 2	Byte 3	Byte 4
Word	Description			
643, 644	S/C status number 1			
645, 646	S/C status number 2			
647, 648	S/C status number 3			
649	Chopper motor temperature (°C)		Scanner motor temperature (°C)	
650	-6.735V		Signal ground (TV)	
651	ELM temperature (°C)		Calibration lamp temperature (°C)	
652	AC supply TOMS (V)		AC supply ELM (V)	
653	Spare		Housing temperature (°C)	
654	+10V (TV)		+12V (TV)	
655	+60V (TV)		PMT temperature (°C)	
656	Electronic temperature (°C)		Signal ground (TV)	
657	ELM signal ground (TV)		ELM +10V (TV)	
658	ELM +12V (TV)		Chopper motor current (TV)	
659	Housing temperature (°C)		Wall gradient (°C)	
	(continued)			

Table 6.5 (continued)

	Byte 1	Byte 2	Byte 3	Byte 4
Word	Description			
660	TOMS high voltage (TV)		Spare	
661	Digital B number 1			
662	Digital B number 2			
663	Digital B number 3			
664	Digital A status major frame 0			
665	Digital A status major frame 40			

* ^{o}C = degrees centigrade
V = volts
TV = telemetry volts
ELM = electronic module

Table 6.6*

Format of Last Record on RUT-T Data Files

	Byte 1	Byte 2	Byte 3	Byte 4
Word	Description			
1	Block identifier (Figure 6.1)			
2	Data orbit number		Day of year at end of file	
3	Negative logical sequence number		File number	
4-6	Spares			
7	GMT time of day at end of file (seconds)			
8	Subsatellite latitude at end		Subsatellite longitude at end	
9	Number of UFO records read			
10	Number of RUT-T records written			
11	Number of records rejected for I/O error			
12	Number of TOMS scans rejected for power off			
13	Number of TOMS scans rejected for mode error			
14	Number of TOMS with chopper out of sync.			
15	Number of TOMS scans with scanner out of sync.			
16	Number of TOMS scans with diffuser moving			
17	Number of TOMS scans in normal scan mode			
18	Number of TOMS scans in single step mode			
19	Number of TOMS scans in stowed mode			
20	Number of TOMS scans in scan off mode			
21	Number of TOMS scans in view diffuser mode			
22	Number of TOMS scans in wavelength calibration mode			
23	Number of TOMS scans in electronic calibration mode			
24	Number of TOMS scans with diffuser deployed at TOMS			
25	Number of samples with exponent = 7			
26	Number of scans with TOMS mercury lamp on			
	(continued)			

Table 6.6 (continued)

Word	Description
27-30	Spares
31	Average value of TOMS chopper motor temperature
32	Standard deviation for word 31
33	Minimum value for word 31
34	Maximum value for word 31
35	Number of data points for word 31
36-40	As words 31 to 35 for TOMS scanner motor temperature
41-45	As words 31 to 35 for -6.375V, thermistor bias
46-50	As words 31 to 35 for signal ground
51-55	As words 31 to 35 for ELM temperature
56-60	As words 31 to 35 for TOMS calibration lamp temperature
61-65	As words 31 to 35 for TOMS AC supply voltage
66-70	As words 31 to 35 for ELM AC supply voltage
71-75	As words 31 to 35 for TOMS housing temperature
76-80	As words 31 to 35 for TOMS +10V thermistor bias
81-85	As words 31 to 35 for TOMS +12V supply
86-90	As words 31 to 35 for TOMS +60V supply
91-95	As words 31 to 35 for TOMS PMT temperature
96-100	As words 31 to 35 for TOMS electrometer temperature
101-105	As words 31 to 35 for TOMS signal ground
106-110	As words 31 to 35 for ELM signal ground
111-115	As words 31 to 35 for ELM +10V thermistor bias
116-120	As words 31 to 35 for ELM +12V supply
	(continued)

Table 6.6 (continued)

Word	Description
121-125	As words 31 to 35 for ELM TOMS chopper motor current
126-130	As words 31 to 35 for ELM TOMS housing temperature
131-135	As words 31 to 35 for ELM TOMS wall gradient
136-140	As words 31 to 35 for TOMS high voltage monitor
141-666	Spares

* Words 2(a,b), 3(a,b) and 8(a,b) are integer (I*2), words 7, 9-26 are integer (I*4), and the rest are floating point (R*4) numbers.
2664 bytes/record.

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(6) "Second Year Addendum to the 'User's Guide for the Total Ozone Mapping Spectrometer (TOMS) Instrument First Year Ozone-T Data Set,'" Available January 1983 from Systems and Applied Sciences Corp., Riverdale, MD.

(7) "Data Inventory for the Solar Backscattered Ultraviolet (SBUV) and the Total Ozone Mapping Spectrometer (TOMS) RUT-S and RUT-T Data Sets: October 31, 1978 to November 1, 1980," Available March 1983 from Systems and Applied Sciences Corp., Riverdale, MD.

APPENDICES

APPENDIX A

Table A.1

Wavelength Channels for SBUV and TOMS

SBUV Vacuum Wavelength (nm)	TOMS Vacuum Wavelength (nm)
255.652	380.014
273.608	359.962
283.099	339.861
287.702	331.253
292.289	317.512
297.586	312.514
301.972	
305.872	
312.565	
317.561	
331.261	
339.892	
343.3 (Photometer)	

APPENDIX B
DESCRIPTION OF MERGED DATA ON RUT-S AND -T

The RUT tapes for SBUV and TOMS contain data from several different sources. Along with the uncalibrated scan data these tapes also contain colocated cloud data measured by the THIR instrument, terrain pressure in millibars and snow/ice thickness in tenths of inches for each IFOV of SBUV and TOMS. In the following three sections the details of each type of merged data will be discussed.

B.1 CLOUD DATA FROM THIR

Colocated cloud data on the CLT tape is generated by using infrared radiance measurements taken by the Temperature Humidity Infrared Radiometer (THIR) onboard Nimbus 7. This two channel instrument takes measurements at 11.5 mm and 6.7 mm channels during both day and night. The 11.5 mm channel is used to obtain information about cloud cover and temperatures of the cloud tops, land and ocean surfaces. The 6.7 mm channel, originally intended to provide information about cirrus clouds and moisture in the upper troposphere and stratosphere, is not used in cloud determination. For more details of this system see Reference 4.

The IFOV of the 11.5 mm channel provides a ground coverage of 7 km x 7 km at the subsatellite point and 24 km x 15 km at the furthest off nadir point. In classifying radiances associated with surface, low, medium and high clouds on the CLT tape, an independently obtained, twelve month global climatological data base which contains surface/low, low/medium, medium/high height breakpoints and temperature values at each level, is used. Radiance samples are separated into these four categories and sample populations are calculated by processing each orbit of THIR data scan by scan, and placing it into SBUV and TOMS IFOV histogram bins by location. This data on the input CLT tape is used during the RUT-S and -T processing to compute average cloud pressure in mbar and percent cloudiness which are then written on the RUT-S and -T tapes.

<u>Computation of Average Cloud Pressure</u>

The average pressure of the cloud tops in the IFOV in mbars is computed using:

$$P_{cloud} = 1013.25*(1-H*0.02257)^{5.256} \qquad \text{(B-1)}$$

H is the average cloud height in km, computed as follows:

$$H = \frac{H_L * N_L + H_M * N_M + H_H * N_H}{N_L + N_M + N_H} \qquad \text{(B-2)}$$

N_L, N_M and N_H are low, medium and high cloud populations on the CLT tape. H_L, H_M and H_H are given in terms of three height breakpoints H_1, H_2 and H_3; and three radiance breakpoints B_1, B_2 and B_3 corresponding to surface/low, low/medium, medium/high cloud boundaries. (H_2 = 2 Km, H_3 = 7,6, or 4 km for equator, mid latitudes and polar regions respectively. H_1 is taken to be zero).

$$H_L = H_1 - (H_2 - H_1) * \frac{\text{Log}(R_L) - \text{Log}(B_1)}{\text{Log}(B_2) - \text{Log}(B_1)} \qquad \text{(B-3a)}$$

$$H_M = H_2 + (H_3 - H_2) * \frac{\text{Log}(R_M) - \text{Log}(B_2)}{\text{Log}(B_3) - \text{Log}(B_2)} \qquad \text{(B-3b)}$$

$$H_H = H_2 + (H_3 - H_2) * \frac{\text{Log}(R_H) - \text{Log}(B_2)}{\text{Log}(B_3) - \text{Log}(B_2)} \qquad \text{(B-3c)}$$

Here R_L, R_M and R_H are mean radiances corresponding to low, medium and high clouds.

Computation of Percent Cloudiness

The percentage of the IFOV covered by clouds is computed from:

$$\% \text{ cloudiness} = \frac{N_L + N_M + N_H}{N_S + N_L + N_M + N_H} * 100\% \qquad \text{(B-4)}$$

where N_S is the surface sample population.

B.2 TERRAIN PRESSURE DATA SET

This data set was derived from a terrain height data set obtained from the National Oceanic and Atmospheric Administration (NOAA). Terrain heights in km were converted to mbars using Eq. (B-1). The entire globe is divided into $2.5^o \times 2.5^o$ latitude and longitude cells with terrain pressure given for each cell. A total of 10585 values are given. A two-dimensional interpolation procedure using the four closest grid points is used to find the value of terrain pressure for a given SBUV or TOMS IFOV.

B.3 SNOW/ICE DATA SET

This data set was obtained from the Air Force Global Weather Center in the form of 2 tapes per month of daily global snow/ice thicknesses in millimeters. This data is on northern hemispheric and southern hemispheric polar stereographic maps, each represented by a grid of 512 by 512 points. This data is mapped onto a $1^{\circ} \times 1^{\circ}$ latitude-longitude grid with a total of 64800 points. The snow/ice thickness for each latitude-longitude cell is obtained by using the value for the nearest central polar stereographic cell. The units are changed to tenths of inches.

APPENDIX C

HOUSEKEEPING DATA CONVERSION AND TOMS SCANNER POSITION CODES

C.1 ANALOG HOUSEKEEPING POSITION CODES DATA

The functions included in the analog housekeeping data are shown in Table C.1. The columns marked SBUV and TOMS indicate if a particular function should be summarized on the RUT-S or RUT-T tapes, respectively. The column labeled 'Convert' indicates whether or not the conversion of equation C.1 should be used.

The temperature in degrees Celsius can be obtained as follows:

$$T(^{\circ}C) = \frac{10^{6}}{1028 + 239.3\ \ln R_t + 0.156\ (\ln R_t)^3} - 273.15 \qquad \text{(C.1)}$$

where R_t in ohms is:

$$R_t(\text{ohms}) = \frac{10^{4}}{1.01\ \frac{2V_{em}}{V_{TM}}\ -1}$$

and,

V_{em} = analog thermistor bias output in telemetry volts.

V_{TM} = analog temperature channel output in telemetry volts.

Table C.1

Analog Housekeeping Data

Function	Name	SBUV	TOMS	Convert	Scaling
13101	SBUV chopper motor temperature	X		Yes	No
13102	SBUV cam motor temperature	X		Yes	No
13103	SBUV diffuser motor temperature	X		Yes	No
13104	SBUV diffuser plate stow temperature	X		Yes	No
13105	TOMS chopper motor temperature		X	Yes	
13106	TOMS scanner motor temperature		X	Yes	
13107	-6.375v thermistor bias	X	X	No	No
13108	Signal ground	X	X	No	No
13109	ELM temperature	X	X	Yes	No
13110	SBUV calibration lamp temperature	X		Yes	No
13111	TOMS calibration lamp temperature		X	Yes	
13112	SBUV AC supply voltage	X		No	No
13113	TOMS AC supply voltage		X	No	
13114	ELM AC supply voltage	X	X	No	No

Table C.1 (continued)

Function	Name	SBUV	TOMS	Convert	Scaling
13115	SBUV housing temperature	X		Yes	No
13116	TOMS housing temperature		X	Yes	
13201	SBUV chopper not sync				
13202	TOMS chopper not sync				
13203	SBUV cam encoder in sync				
13204	TOMS scanner not sync				

C.2 DIGITAL A HOUSEKEEPING DATA

The functions included in the Digital A housekeeping data are shown in Table C.2. The columns marked SBUV and TOMS indicate if a particular function is to be summarized on the RUT-S and RUT-T tape, respectively. The column labeled 'Convert' references the appropriate equation number for the conversion.

Conversion Equations

The Digital A housekeeping data will be a number, in counts, between 0 and 4000. All data include an offset, indicated by the "signal ground" functions in the Digital A housekeeping data. This signal ground must be subtracted from each measurement before conversion. (Subtract #1 from #'s 2 to 7, #11 from #'s 12 to 19, and # 21 from #'s 22 to 29). In all of the following, V_{TLM} refers to the appropriate Digital A housekeeping data, in telemetry volts.

$$V_{TLM} = (\text{counts} - \text{offset})$$

+10v Thermistor Bias, V_B:

$$V_B = \frac{V_{TLM}}{0.6560} \qquad \text{(C.2)}$$

+12v Supply, V_{S12}:

$$V_{S12} = 2.01\,(V_{TLM}) \qquad \text{(C.3)}$$

+60v Supply, V_{S60}:

$$V_{S60} = 11.942(V_{TLM}) \qquad \text{(C.4)}$$

High Voltage Monitor, V_{HV}:

$$V_{HV} = 400\ V_{TLM} \tag{C.5}$$

Temperature, T, in degrees celsius is obtained by

$$T(^{o}C) = \frac{10^{6}}{930.83 + 221.75\ \ln R_t + 0.12511\ (\ln R_t)^{3}} - 273.15 \tag{C.6}$$

where

$$R_t = \frac{26.87 \times 10^{3}\ \frac{C_{TLM}}{C_B}}{1.3532 - \frac{C_{TLM}}{C_B}}$$

where C_{TLM} = counts - offset, corresponding to V_{TLM} and C_B are counts corresponding to V_B as defined in Equation (C.2). Bias voltage in #2 should be used with #6 and #7, #12 with #16 and #17, and #22 with #26, #27, and #28.

Chopper motor current, I_m in mA:

$$I_m = 12.5\ (V_{TLM}) \tag{C.7}$$

Differential temperatures, T:

$$T(^{\circ}C) = \frac{2486.5 - C_{TLM}}{0.4713T - 42.7} \tag{C.8}$$

where T is the temperature found in the preceding equation. Use #16 to convert #18 and #17 to convert #19. C_{TLM} are counts corresponding to V_{TLM} after the offset has been subtracted.

C.3 TOMS SCANNER POSITION CODES

TOMS scanner position codes are listed in Table C.3.

Table C.2

Digital A Housekeeping Data

#	Function	SBUV	TOMS	Convert
1	TOMS signal ground		X	(counts/4000) x 8
2	TOMS +10v thermistor bias		X	C.2
3	TOMS +12v supply		X	C.3
4	TOMS +60v supply		X	C.4
5	TOMS high voltage monitor		X	C.5
6	TOMS photomultipler tube temperature		X	C.6
7	TOMS electrometer temperature		X	C.6
8	Unused			
9	Unused			
10	Unused			
11	ELM signal ground	X	X	(counts/4000) x 8
12	ELM +10v thermistor bias	X	X	C.2
13	ELM +12v supply	X	X	C.3
14	ELM SBUV chopper motor current	X		C.7
15	ELM TOMS chopper motor current		X	C.7
16	ELM SBUV housing temperature	X		C.6
17	ELM TOMS housing temperature		X	C.6
18	ELM SBUV wall gradient	X		C.8
19	ELM TOMS wall gradient		X	C.8
20	Unused			
21	SBUV signal ground	X		(counts/4000) x 8
22	SBUV +10v thermistor bias	X		C.2
23	SBUV +12v supply	X		C.3
24	SBUV +60v supply	X		C.4

(continued)

Table C.2 (continued)

#	Function	SBUV	TOMS	Convert
25	SBUV reference photodiode temperature	X		C.6
26	SBUV photometer photodiode temperature	X		C.6
27	SBUV electrometer temperature	X		C.6
28	SBUV photomultiplier tube temperature	X		C.6
29	SBUV high voltage monitor	X		C.5
30	Unused			

Table C.3

TOMS Scanner Position Codes

Step No. (Dec)	Step No. (Hex)	Encoder Out (Binary) A B C D E F	Encoder Out (Hex Notation)	Notes
000	00	0 0 0 0 0 0	00	Scene 0
001	01	0 0 1 0 0 1	09	Scene 1
002	02	0 0 1 0 1 1	0B	Scene 2
003	03	0 0 1 0 1 0	0A	Scene 3
004	04	0 0 1 1 1 0	0E	Scene 4
005	05	0 0 1 1 1 1	0F	Scene 5
006	06	0 0 1 1 0 1	0D	Scene 6
007	07	0 0 1 1 0 0	0C	Scene 7
008	08	0 1 1 1 0 0	1C*	Scene 8
009	09	0 1 0 1 0 0	14	Scene 9
010	0A	0 1 0 1 0 1	15	Scene 10
011	0B	0 1 0 1 1 1	17	Scene 11
012	0C	0 1 0 1 1 0	16	Scene 12
013	0D	0 1 0 0 1 0	12	Scene 13
014	0E	0 1 0 0 1 1	13	Scene 14
015	0F	0 1 0 0 0 1	11	Scene 15
016	10	0 1 1 0 0 1	19	Scene 16
017	11	0 1 1 0 1 1	1B	Scene 17 (nadir)
018	12	0 1 1 0 1 0	1A	Scene 18
019	13	0 1 1 1 1 0	1E	Scene 19
020	14	0 1 1 1 1 1	1F	Scene 20
021	15	0 1 1 1 0 1	1D	Scene 21
022	16	0 1 1 1 0 0	1C*	Scene 22
023	17	1 1 1 1 0 0	3C	Scene 23
024	18	1 1 1 1 0 1	3D	Scene 24
025	19	1 1 1 1 1 1	3F	Scene 25
026	1A	1 1 1 1 1 0	3E	Scene 26
027	1B	1 1 1 0 1 0	3A	Scene 27
028	1C	1 1 1 0 1 1	3B	Scene 28
029	1D	1 1 1 0 0 1	39	Scene 29
030	1E	1 1 0 0 0 1	31	Scene 30
031	1F	1 1 0 0 1 1	33	Scene 31
032	20	1 1 0 0 1 0	32	Scene 32
033	21	1 1 0 1 1 0	36	Scene 33
034	22	1 1 0 1 0 0	34	Scene 34
069	45	1 1 0 1 1 1	37	Stow
104	68	1 0 0 1 1 0	26	Diffuser
Thirty-four steps		1 1 0 1 0 1	35	Sector 3
Thirty-four steps		1 0 0 1 1 1	27	Sector 1
Fifteen steps		1 0 0 1 0 0	24	Sector 2

*Encoder out for Scene 8 and Scene 22 were erroneously assigned the same value (hexadecimal 1C). If using the Encoder out codes, compare 1C with previous value to determine if this is Scene 8 or Scene 22.

APPENDIX D

D.1 RUT-S Tape Catalog - First Year

Week Number	Orbit Range(1)	Day Range(2)	Number of Files(3)
01	100-162	1978 304-308	65
02	163-258	309-315	96
03	259-355	316-322	81
04	356-452	323-329	85
05	453-549	330-336	86
06	564-645	338-343	82
07	647-742	344-350	71
08	743-825	351-356	85
09	841-936	358-364	82
10	943-1032	356-006	72
11	1034-1130	1979 007-013	86
12	1131-1213	014-020	66
13	1228-1323	021-027	94
14	1324-1420	028-034	99
15	1421-1517	035-041	85
16	1518-1614	042-048	84
17	1617-1710	049-055	80

(1) See the data inventory (ref. 7) for orbit availability for each day.

(2) The year 1 data set begins on 10/31/78 (day 304) and ends on 11/3/79 (day 307). The year 2 data set is from 11/4/79 (day 308) to 11/1/80 (day 306). Data on the tapes is grouped into days based on the starting time of the orbits. Therefore, minor variations in day ranges may be noted as compared to the data inventory which groups orbits into days based on the ending time of the orbits.

(3) Number of files includes the header and trailer files plus one file for each orbit. In some cases for first year RUT data, the trailer file may be absent. Beginning with year 2, each tape has a trailer documentation file following the trailer file.

RUT-S Tape Catalog
First Year
(continued)

Week Number	Orbit Range	Day Range	Number of Files
18	1711-1807	1979 056-062	95
19	1808-1904	063-069	67
20	1905-1986	070-075	82
21	2003-2097	077-083	79
22	2101-2194	084-090	85
23	2196-2291	091-097	97
24	2292-2374	093-103	85
25	2389-2484	105-111	97
26	2500-2580	113-118	63
27	2582-2678	119-125	74
28	2679-2775	126-132	81
29	2776-2871	133-139	95
30	2886-2968	141-146	84
31	2969-3065	147-153	72
32	3066-3148	154-159	69
33	3163-3258	161-167	84
34	3273-3355	169-174	62
35	3357-3452	175-181	93
36	3453-3548	182-188	98
37	3550-3645	189-195	95
38	3646-3742	196-202	98
39	3743-3839	203-209	95
40	3840-3935	210-216	98
41	3937-4032	217-223	93
42	4033-4129	224-230	99
43	4131-4226	231-237	97

RUT-S Tape Catalog
First Year
(continued)

Week Number	Orbit Range	Day Range	Number of Files
44	4227-4322	1979 238-244	96
45	4324-4419	245-251	96
46	4420-4514	252-258	95
47	4519-4613	259-265	92
48	4614-4710	266-272	99
49	4711-4805	273-279	97
50	4807-4902	280-286	97
51	4904-4998	287-293	95
52	5001-5096	294-300	96
53	5097-5193	301-307 **	99

**Last orbit ends on day 308, 11/4/79.

D.2 RUT-S Tape Catalog - Second Year

Week Number	Orbit Range	Day Range	Number of Files
54	5194-5290	1979 308-314	100
55	5291-5387	315-321	100
56	5388-5483	322-328	99
57	5484-5579	329-335	97
58	5581-5677	336-342	100
59	5678-5772	343-349	95
60	5775-5870	350-356	98
61	5871-5967	357-363	100
62	5968-6064	364-005	100
63	6065-6160	1980 006-012	97
64	6161-6157	013-019	86
65	6258-6354	020-026	98
66	6355-6451	027-033	98
67	6452-6547	034-040	97
68	6548-6644	041-047	98
69	6645-6740	048-054	99
70	6742-6838	055-061	97
71	6839-6934	062-068	99
72	6935-7031	069-075	99
73	7032-7127	076-082	99
74	7129-7224	083-089	98
75	7225-7321	090-096	100
76	7322-7419	097-103	100
77	7420-7514	104-110	98
78	7516-7611	111-117	98
79	7612-7708	118-124	97
80	7709-7805	125-131	99
81	7806-7901	132-138	98
82	7903-7998	139-145	98
83	7999-8095	146-152	99
84	8096-8191	153-159	99

RUT-S Tape Catalog

Second Year

(continued)

Week Number	Orbit Range	Day Range	Number of Files
85	8193-8288	1980 160-166	99
86	8290-8385	167-173	99
87	8386-8482	174-180	100
88	8483-8578	181-187	99
89	8580-8675	188-194	97
90	8676-8772	195-201	100
91	8773-8869	202-208	99
92	8870-8966	209-215	100
93	8967-9062	216-222	99
94	9063-9159	223-229	99
95	9160-9256	230-236	100
96	9258-9353	237-243	98
97	9354-9449	244-250	99
98	9450-9546	251-257	99
99	9547-9643	258-264	99
100	9644-9740	265-271	99
101	9741-9836	272-278	99
102	9838-9933	279-285	97
103	9934-10030	286-292	100
104	10031-10126	293-299	100
105	10128-10223	300-306 **	98

**Last orbit ends on day 307, 11/2/80

APPENDIX E

E.1 RUT-T Tape Catalog - First Year

Week Number[1]	Orbit Range[2]	Day Range[3]	Number of Files[4]
01A	100-133	1978 304-306	036
01B	134-162	306-308	031
02A	165-194	309-311	031
02B	195-227	311-313	033
02C	228-258	313-315	032
03A	259-304	316-319	048
03B	305-355	319-322	034
04A	356-429	323-328	062
04B	430-452	328-329	025
05A	453-522	330-335	061
05B	523-549	335-336	027
06A	564-620	338-342	058
06B	621-645	342-343	026

(1) A,B,C refer to the number of tapes needed to make up one week's data.

(2) See the data inventory (ref. 7) for orbit availability for each day.

(3) The year 1 data set begins on 10/31/78 (day 304) and ends on 11/3/79 (day 307). The year 2 dataset is from 11/4/79 (day 308) to 11/1/80 (day 306). Data on the tapes is grouped into days based on the starting time of the orbits. Therefore, minor variations in day ranges may be noted as compared to the data inventory which groups orbits into days based on the ending time of the orbits.

(4) Number of files includes the header and trailer files on each tape plus one file for each orbit. In some cases for first year RUT data, the trailer file may be absent. Beginning with year 2, each tape has a trailer documentation file following the trailer file.

RUT-T Tape Catalog
First Year
(continued)

Week Number	Orbit Range	Day Range	Number of Files
07A	647-734	1978 344-350	063
07B	735-742	350-350	010
08A	743-803	351-355	063
08B	804-825	355-356	024
09A	841-903	358-362	049
09B	904-936	362-364	035
10A	943-1008	365-005	049
10B	1009-1032	1979 005-006	026
11A	1034-1107	007-012	063
11B	1108-1130	012-013	025
12A	1131-1209	014-019	062
12B	1210-1213	019-020	006
13A	1228-1291	021-025	064
13B	1292-1323	025-027	032
14A	1324-1384	028-032	062
14B	1385-1420	032-034	038
15A	1421-1481	035-039	063
15B	1482-1517	039-041	024
16A	1518-1593	042-047	063
16B	1594-1614	047-048	023
17A	1617-1692	049-054	062
17B	1693-1710	054-055	020
18A	1711-1777	056-060	068
18B	1778-1807	060-062	029
19A	1808-1904	063-069	067
20A	1905-1968	070-074	064
20B	1969-1986	074-075	020
21A	2003-2080	077-082	062

RUT-T Tape Catalog
First Year
(continued)

Week Number	Orbit Range	Day Range	Number of Files
21B	2081-2097	1979 082-083	018
22A	2101-2172	084-089	063
22B	2173-2194	089-090	024
23A	2196-2258	091-095	064
23B	2259-2291	095-097	035
24A	2292-2350	098-102	061
24B	2351-2374	102-103	026
25A	2389-2449	105-109	062
25B	2450-2484	109-111	037
26A	2500-2580	113-118	064
27A	2582-2647	119-123	066
27B	2648-2678	123-125	010
28A	2679-2757	126-131	066
28B	2758-2775	131-132	015
29A	2776-2839	133-137	064
29B	2840-2871	137-139	033
30A	2886-2947	141-145	063
30B	2948-2968	145-146	023
31A	2969-3055	147-153	062
31B	3056-3065	153-153	012
32A	3066-3125	154-158	048
32B	3126-3148	158-159	023
33A	3163-3221	161-165	047
33B	3222-3258	165-167	039
34A	3273-3355	169-174	048
35A	3357-3402	175-178	046
35B	3403-3450	178-181	047
35C	3451-3452	181-181	004

RUT-T Tape Catalog
First Year
(continued)

Week Number	Orbit Range	Day Range	Number of Files
36A	3453-3501	1979 182-185	051
36B	3502-3548	185-188	049
37A	3550-3589	189-191	042
37B	3590-3640	191-195	050
37C	3641-3645	195-195	007
38A	3646-3695	196-199	051
38B	3696-3738	199-202	045
38C	3739-3742	202-202	006
39A	3743-3785	203-206	043
39B	3786-3838	206-209	053
39C	3839-3839	209-209	003
40A	3840-3885	210-213	048
40B	3886-3927	213-216	044
40C	3928-3935	216-216	010
41A	3937-3980	217-220	044
41B	3981-4027	220-223	046
41C	4028-4032	223-223	007
42A	4033-4079	224-227	049
42B	4080-4124	227-230	047
42C	4125-4129	230-230	007
43A	4131-4171	231-233	043
43B	4172-4218	234-237	049
43C	4219-4226	237-237	009
44A	4227-4275	238-241	049
44B	4276-4320	241-244	047
44C	4321-4322	244-244	004
45A	4324-4363	245-247	042
45B	4364-4405	247-250	044

RUT-T Tape Catalog
First Year
(continued)

Week Number	Orbit Range	Day Range	Number of Files
45C	4406-4419	1979 251-251	014
46A	4420-4463	252-255	044
46B	4464-4505	255-258	044
46C	4506-4514	258-258	011
47A	4519-4567	259-262	046
47B	4567-4606	262-265	042
47C	4607-4613	265-265	009
48A	4614-4652	266-268	041
48B	4653-4687	268-271	037
48C	4688-4710	271-272	025
49A	4711-4746	273-275	038
49B	4747-4781	275-278	037
49C	4782-4804	278-279	025
50A	4807-4847	280-282	043
50B	4847-4890	282-286	045
50C	4891-4902	286-286	014
51A	4904-4943	287-289	042
51B	4944-4980	289-292	039
51C	4981-4998	292-293	018
52A	5001-5042	294-297	043
52B	5043-5077	297-299	036
52C	5078-5096	299-300	021
53A	5097-5129	301-303	035
53B	5130-5170	303-306	043
53C	5171-5193	306-307	025

** Last Orbit ends on day 308, 4 November 1979.

E.2 RUT-T Tape Catalog - Second Year

Week Number	Orbit Range	Day Range	Number of Files
54A	5194-5233	1979 308-310	43
54B	5234-5274	310-313	44
54C	5275-5290	313-314	19
55A	5291-5330	315-317	43
55B	5331-5366	318-320	39
55C	5367-5387	320-321	24
56A	5388-5426	322-324	42
56B	5427-5461	324-327	38
56C	5462-5483	327-328	25
57A	5484-5519	329-331	39
57B	5520-5567	331-334	49
57C	5568-5579	335-335	15
58A	5581-5621	336-338	44
58B	5622-5658	339-341	40
58C	5659-5678	341-342	23
59A	5679-5711	343-345	36
59B	5712-5744	345-347	36
59C	5745-5772	347-349	30
60A	5775-5809	350-352	38
60B	5810-5853	352-355	45
60C	5854-5870	355-356	21
61A	5871-5906	357-359	39
61B	5907-5954	359-363	51
61C	5955-5967	363-363	16
62A	5968-6009	364-002	45
62B	6010-6042	1980 002-004	47
62C	6054-6064	005-005	14
63A	6065-6110	006-009	47
63B	6111-6150	009-012	43
63C	6151-6160	012-012	13
64A	6161-6200	013-015	43

RUT-T Tape Catalog
Second Year
(continued)

Week Number	Orbit Range	Day Range	Number of Files
64B	6201-6237	1980 015-018	40
64C	6238-6257	018-019	23
65A	6258-6293	020-022	39
65B	6294-6337	022-025	45
65C	6338-6354	025-026	20
66A	6355-6397	027-030	45
66B	6398-6438	030-033	43
66C	6439-6450	033-033	16
67A	6452-6492	034-037	44
67B	6493-6535	037-040	44
67C	6536-6547	040-040	15
68A	6548-6580	041-043	36
68B	6581-6613	043-045	36
68C	6614-6644	045-047	33
69A	6645-6679	048-050	38
69B	6680-6717	050-053	41
69C	6718-6740	053-054	26
70A	6742-6776	055-057	36
70B	6777-6809	057-059	36
70C	6810-6838	060-061	32
71A	6839-6882	062-065	47
71B	6883-6924	065-068	45
71C	6925-6934	068-068	13
72A	6935-6971	069-071	40
72B	6972-7009	071-074	41
72C	7010-7031	074-075	24
73A	7032-7064	076-078	36
73B	7065-7104	078-081	43
73C	7105-7127	081-082	26

RUT-T Tape Catalog
Second Year
(continued)

Week Number	Orbit Range	Day Range	Number of Files
74A	7129-7168	1980 083-085	43
74B	7169-7209	086-088	43
74C	7210-7224	088-089	18
75A	7225-7269	090-093	48
75B	7270-7305	093-095	39
75C	7306-7321	095-096	19
76A	7322-7364	097-100	45
76B	7365-7398	100-102	37
76C	7399-7418	102-103	24
77A	7420-7454	104-106	38
77B	7455-7493	106-109	42
77C	7494-7514	109-110	24
78A	7516-7556	111-114	44
78B	7557-7607	114-117	52
78C	7608-7611	117-117	07
79A	7612-7646	118-120	36
79B	7647-7679	120-122	36
79C	7680-7708	123-124	32
80A	7709-7747	125-127	42
80B	7748-7785	127-130	40
80C	7786-7805	130-131	23
81A	7806-7842	132-134	40
81B	7843-7882	134-137	43
81C	7883-7901	137-138	22
82A	7903-7943	139-142	43
82B	7944-7990	142-145	49
82C	7991-7998	145-145	11
83A	7999-8038	146-148	42
83B	8039-8075	148-151	39
83C	8076-8095	151-152	23

RUT-T Tape Catalog
Second Year
(continued)

Week Number	Orbit Range	Day Range	Number of Files
84A	8096-8131	1980 153-155	39
84B	8132-8167	155-158	39
84C	8168-8191	158-159	27
85A	8193-8231	160-162	42
85B	8232-8273	162-165	45
85C	8274-8288	165-166	18
86A	8290-8333	167-170	45
86B	8334-8379	170-173	49
86C	8380-8385	173-173	09
87A	8386-8418	174-176	36
87B	8419-8451	176-178	36
87C	8452-8482	178-180	34
88A	8483-8520	181-183	41
88B	8521-8554	183-186	37
88C	8555-8578	186-187	27
89A	8580-8614	188-190	36
89B	8615-8654	190-193	43
89C	8655-8675	193-194	24
90A	8676-8715	195-197	43
90B	8716-8753	197-200	41
90C	8754-8772	200-201	22
91A	8773-8812	202-204	42
91B	8813-8846	204-207	37
91C	8847-8869	207-208	26
92A	8870-8906	209-211	40
92B	8907-8940	211-214	37
92C	8941-8966	214-215	29
93A	8967-8999	216-218	36
93B	9000-9037	218-221	41

RUT-T Tape Catalog
Second Year
(continued)

Week Number	Orbit Range	Day Range	Number of Files
93C	9038-9062	1980 221-222	28
94A	9063-9095	223-225	36
94B	9096-9135	225-228	42
94C	9136-9159	228-229	27
95A	9160-9198	230-232	42
95B	9199-9244	232-236	49
95C	9245-9256	236-236	15
96A	9258-9294	237-239	40
96B	9295-9335	239-242	43
96C	9336-9353	242-243	21
97A	9354-9385	244-246	35
97B	9386-9423	246-249	41
97C	9424-9449	249-250	29
98A	9450-9489	251-253	43
98B	9490-9529	253-256	42
98C	9530-9546	256-257	20
99A	9547-9585	258-260	42
99B	9586-9621	260-263	38
99C	9622-9643	263-264	25
100A	9644-9681	265-267	41
100B	9682-9716	267-270	38
100C	9717-9740	270-271	26
101A	9741-9772	272-274	35
101B	9773-9810	274-277	41
101C	9811-9836	277-278	29
102A	9838-9879	279-282	44
102B	9880-9924	282-285	47
102C	9925-9933	285-285	12
103A	9934-9972	286-288	42
103B	9973-10007	288-291	38

RUT-T Tape Catalog
Second Year
(continued)

Week Number	Orbit Range	Day Range	Number of Files
103C	10008-10030	1980 291-292	26
104A	10031-10066	293-295	39
104B	10067-10101	295-298	38
104C	10102-10126	298-299	28
105A	10128-10159	300-302	35
105B	10160-10197	302-305	41
105C	10198-10223	305-306 **	29

** Last orbit ends on day 307, 11/2/80

APPENDIX F

Data Availability and Cost

RUT-S and RUT-T data tapes are archived and available from the National Space Science data Center (NSSDC). The NSSDC will furnish limited quantities of data to qualified users without charge. The NSSDC may establish a nominal charge for production and dissemination if a large volume of data is requested. Whenever a charge is required, a cost estimate will be provided to the user prior to filling the data request.

Domestic requests for data should be addressed to:

National Space Science Data Center
Code 601
NASA/Goddard Space Flight Center
Greenbelt, MD 20771

All requests from foreign researchers must be specifically addressed to:

Director, World Data Center A for Rockets and Satellites
Code 601
NASA/Goddard Space Flight Center
Greenbelt, MD 20771 USA

When ordering data from either NSSDC or the World Data Center, a user should specify why the data are needed, the subject of his work, the name of the organization with which he is connected, and any government contracts he may have for performing his study. Each request should specify the experiment data desired, the time period of interest, plus any other information that would facilitate the handling of the data request.

A user requesting data on magnetic tapes should provide additional information concerning the plans for using the data, i.e. what computers and operating systems will be used. In this context, the NSSDC is compiling a library of routines that can unpack or transform the contents of many of the data sets into formats that are appropriate for the user's computer. NSSDC will provide, upon request, information concerning its services.

When requesting data on magnetic tape,the user must specify whether he will supply new tapes prior to the processing, or return the original NSSDC tapes after the data have been copied.

Data product order forms may be obtained from NSSDC/World Data Center A.

Data inventories for SBUV and TOMS (ref. 7) are available on request from NSSDC or from A. J. Fleig, Ozone Processing Team Manager, Code 910.2, Goddard Space Flight Center, Greenbelt, Maryland 20771.

APPENDIX G

Glossary of Abbreviations

ACS	Attitude Control System
CLT	Cloud-SBUV/TOMS Tape
CZCS	Coastal Zone Color Scanner
DSAS	Digital Solar Aspect Sensor
DQLI	Data Quality Loss Interval flag for minor frames - indicates bad data quality
EBCDIC	Extended Binary Coded Decimal Interchange Code (Character or zoned decimal data)
ECAL	Electrical Calibration
ELM	Electronic Module
ERB	Earth Radiation Budget Experiment
FOV	Field of View
IFOV	Instantaneous Field of View
ILT	Image Location Tape
IPD	Information Processing Division, Goddard Space Flight Center — responsible for acceptance of all SBUV/TOMS products prior to archiving; also generates all film products
NBS	National Bureau of Standards
NOPS	Nimbus Observation Processing System — data landing and processing complex that organizes the processing of Nimbus payload data into scientific investigations
PDFC	Project Data Format Code - a unique 2 character code assigned to each archivable product
RUT	Raw Unit Tape
SACC	Science and Applications Computing Center — the Goddard Space Flight Center computing facility
S/C	Spacecraft
STA	Sub Target Area
THIR	Temperature Humidity Infrared Radiometer
TV	Telemetry Volts

T/V	Thermal Vacuum
UFO	User Formatted Output Tape
VIP	Versatile Information Processor

APPENDIX H

Nimbus-4 BUV Archive Products

Since users of Nimbus-7 SBUV/TOMS data may be interested in the Nimbus-4 BUV data as well, the following summary of available Nimbus-4 products has been included. Please note that N-4 BUV data, archived in 1980 was derived from an algorithm different from that of N-7 SBUV/TOMS data.

About 300 tapes resulting from the Nimbus-4 BUV effort have been archived in the National Space Sciences Data Center at GSFC. The large majority of these tapes contain a great deal more detail than the typical user requires.

The complete total ozone and vertical profile data sets are contained on 8 magnetic tapes - 4 compressed total ozone (CTOZ) tapes and 4 compressed profile (CPFL) tapes. The total ozone data set is contained on 4 CTOZ tapes. Each data record on the CTOZ tape contains a single total ozone observation. The CTOZ data record contains 20 data words. The location and time of the observation is given as well as the observed photometer and monochromator radiances for the 4 longest monochromator wavelengths (expressed as N-values), the A-pair, B-pair and recommended total ozone and the recommended reflectivity.

The complete profile data set is contained on 4 CPFL tapes. Each data record on the CPFL tapes contains a single ozone profile observation. The CPFL data record contains 50 words. Besides the location and time of the observation, the data record contains the observed profile at 13 standard levels expressed both as the ozone above in matm-cm and as mass mixing ratios in microgram/gram. In addition, the 8 monochromator N-values between 2555A^o and 3059A^o are given as well as the reflectivity, total ozone, solar zenith angle, radiation anomaly code, pressure levels for peak of the 2735A^o and 3058A^o contribution functions and the parameters of the upper level profile in the exponential altitude model.

The profile data set is substantially smaller than the total ozone data set because samples in the radiation anomaly in the South Atlantic had to be discarded due to large background noise. Thus the record of total ozone observations contained on the CPFL tapes is a subset of that contained on the CTOZ tapes. To obtain the complete total ozone data set, the user should use the CTOZ data set.

The profile data set has been averaged zonally on a daily basis and a Daily Zonal Means for Profiles (DZP) tape has been created. The zonal means have been calculated for both geodetic and geomagnetic coordinates. The geomagnetic zonal means are contained in the DZPM tape. The seven-year daily zonal mean data set is contained on a single tape. Separate tapes have been archived for the geodetic and geomagnetic coordinates.

The magnetic tapes described above are the most convenient data sets available for obtaining the BUV radiance and ozone information. More details concerning the instrument measurements and intermediate parameters derived in the computations can be found in the rest of the data sets: the DTOZ, DPFL, UTAPE and PDB tapes.

The DTOZ (detailed total ozone) tapes contain all the information on the CTOZ tapes plus the uncombined ozones and reflectivities for the A and B-pair at 1.0 and 0.4 atmospheres. The sensitivities of the measurements and the radiances for all 12 monochromator channels and the 12 measurements by the photometer channel are also included. The entire DTOZ data set is contained in 15 1600 BPI tapes each of which covers from 3 month's to 1 year's time. The tape format and catalog for the DTOZ tapes can be found in reference 1 which is available to users from the NSSDC.

Similar to the DTOZ tapes, the DPFL data set contains intermediate parameters in the computation of the ozone profiles such as the selected first guess profile, multiple scattering corrections, differences between the observed and computed radiances (expressed as % Q values) and peaks of each channel's contribution function. Unlike the CPFL tapes, the DPFL tapes contain ozone information for 3 additional levels at 0.5, 0.4 and 0.3 mb. The DPFL tapes also contain error flagged scans that are not present in the CPFL tapes. Such scans were rejected for various reasons stated in reference 2; these scans, though error flagged, may still contain good radiances on C and sigma. The entire DPFL data set is contained in 37 1600 BPI tapes archived in the NSSDC. Each tape covers a period from one to six months. A tape catalog and record format for the DPFL tapes can be found in reference 2.

The Primary Data Base tapes contain the extracted BUV and MUSE (the Monitor of Ultraviolet Solar Energy experiment) instruments' outputs in raw format, the housekeeping functions, the computed image location time (ILT) and the satellite's attitude. The PDB tapes contain orbits in sequential order and include some duplicate orbits that came in with slightly different formats on unsequenced raw data tapes. Each orbit is contained in one file and each tape covers a period from one to 34 weeks depending on the incoming data density. More details about the PDB tapes can be found in reference 3, and its tape catalog can be found in reference 4. A total of 189 tapes containing the entire Primary Data Base has been archived in the NSSDC.

Finally, the U-tapes contain the ultraviolet radiances reduced from the raw data on the PDB. During the daytime, radiances are available from the instruments analog output and are expressed in U-values; at night, however, the radiances are available from the digital output of an event counter and are expressed as pulses (counts) per second. During twilights, radiances are available in both formats. The U-tapes also contain information about the instrument performance as well as a statistical summary of the housekeeping functions. A total of 42 U-tapes has been generated and archived at the NSSDC, each covering 4 to 34 weeks of data depending on data density. A catalog of the U-tapes can be found in reference 4 and its tape format in reference 3.

Nimbus 4 BUV References:

References 1,2 and 4 are available from NSSDC. Reference 3 is available as a NASA Technical Memorandum.

1. Tape formats and descriptions to accompany the total ozone tapes (DTOZ and CTOZ) for the Nimbus-4 BUV Experiment (Release II), November 1977, SASC.
2. Tape formats and descriptions to accompany the ozone profile tapes (DPFL and CPFL) for the Nimbus-4 BUV Experiment, OPT, July 1980.
3. User's Guide to the Nimbus 4 BUV Data Sets, OPT, January 1978, TM - 78069 NASA Goddard Space Flight Center, Greenbelt, MD.
4. N-4 Data Tape Catalogs for the Primary Data Base (PDB) and Radiance (U-Tape) Data Sets, March, 1983, SASC.

1. Report No. NASA RP-1112	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle "User's Guide for the Solar Backscattered Ultraviolet (SBUV) and the Total Ozone Mapping Spectrometer (TOMS) RUT-S and RUT-T Data Sets: October 31, 1978 to November 1, 1980"		5. Report Date June 1983
		6. Performing Organization Code 910
7. Author(s) A.J. Fleig, D.F. Heath, K.F. Klenk, N. Oslik, K.D. Lee, H. Park, P.K. Bhartia, D. Gordon		8. Performing Organization Report No.
9. Performing Organization Name and Address Goddard Space Flight Center Greenbelt, Maryland 20771		10. Work Unit No.
		11. Contract or Grant No. NAS5-27393
		13. Type of Report and Period Covered Reference Publication
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		
		14. Sponsoring Agency Code

15. Supplementary Notes

A. J. Fleig and D. F. Heath: Goddard Space Flight Center, Greenbelt, Maryland.

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16. Abstract

Raw data from the Solar Backscattered Ultraviolet/Total Ozone Mapping Spectrometer (SBUV/TOMS) Nimbus 7 operation from November 1978 to November 1980 are available on computer tape. These data are contained on two separate sets of RUTs (Raw Units Tapes) for SBUV and TOMS, labelled RUT-S and RUT-T respectively. The RUT-S and RUT-T tapes contain uncalibrated radiance and irradiance data, housekeeping data, wavelength and electronic calibration data, instrument field-of-view location and solar ephemeris information. These tapes also contain colocated cloud, terrain pressure and snow/ice thickness data, each derived from an independent source.

The "RUT User's Guide" describes the SBUV and TOMS experiments, the instrument calibration and performance, operating schedules, and data coverage, and provides an assessment of RUT-S and -T data quality. It also provides detailed information on the data available on the computer tapes, including how to order tapes from the National Space Science Data Center.

17. Key Words (Selected by Author(s)) Nimbus 7 SBUV/TOMS, Backscattered Ultraviolet radiation, Solar UV Irradiance		18. Distribution Statement STAR Category 47 Unclassified - Unlimited	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 148	22. Price* A07

*For sale by the National Technical Information Service, Springfield, Virginia 22161.